BELL TELEPHONE MAGAZINE

VOL. XXI FEBRUARY, 1942 NO. 1

WE SHALL JUSTIFY THEIR FAITH
A STATEMENT BY PRESIDENT GIFFORD

TELEPHONE LINES AND AIR DEFENSE

"FREQUENTLY REPRINTED DIRECTORIES"
FOR THE INFORMATION SERVICE

ACROSS THE ROOF OF THE CONTINENT

BILLS FOR 13,000,000 CUSTOMERS

THE MOBILIZATION OF SCIENCE IN
NATIONAL DEFENSE

AMERICAN TELEPHONE & TELEGRAPH CO. • NEW YORK

BELL TELEPHONE MAGAZINE

Continuing the BELL TELEPHONE QUARTERLY

A Medium of Suggestion and a Record of Progress

"The ideal and aim of the American Telephone and Telegraph Company and its Associated Companies is a telephone service for the nation, free, so far as humanly possible, from imperfections, errors, or delays, and enabling anyone anywhere to pick up a telephone and talk to anyone else anywhere else, clearly, quickly and at a reasonable cost."

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We Shall Justify Their Faith 3
Walter S. Gifford

Telephone Lines and Air Defense 4
Judson S. Bradley

"Frequently Reprinted Directories" for the Information Service 17
Jerome D. Towe

Across the Roof of the Continent 26
Stuart Shaw

Bills for 13,000,000 Customers 38
F. Raymond Brewster

The Mobilization of Science in National Defense 48
Frank B. Jewett

For the Record 55

M. R. Sullivan and C. O. Bickelhaupt elected A. T. & T. Vice Presidents—Isaiah Bowman elected an A. T. & T. Director—Net telephone gain in 1941 was 1,360,000

Contributors to This Issue 56

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"SERVICE TO THE NATION IN PEACE AND WAR"

Placed in the lobby of the American Telephone and Telegraph Building in New York after the first World War, this bronze and marble group is today both a symbol and a pledge

WE SHALL JUSTIFY THEIR FAITH

A statement broadcast over a nation-wide radio network on December 15, 1941, eight days after the attack on Pearl Harbor

By WALTER S. GIFFORD

President, American Telephone and Telegraph Company

WE are at war, and I am here tonight to congratulate the men and women of the Bell System for their magnificent handling of the extraordinary demands for telephone service during the past week.

While we of the Bell System — and there are 400,000 of us — are used to meeting emergencies, we know we now face the greatest of all times: an emergency that will require long sustained effort.

I am confident that we shall live up to our tradition that the message must get through, no matter what the obstacles or discouragements. Your achievements under the strain put upon you last week demonstrate that fact. To win the war will take courage, resourcefulness, and hard work. We must and shall win, come what may. Our fellow citizens are counting on us to do our part — and we shall justify their faith.

TELEPHONE LINES AND AIR DEFENSE

Operation of the Aircraft Warning Network, and Co-ordination of Defense Against Enemy Air Attack, Depend Upon a Carefully Designed System Using Existing Communication Facilities

By JUDSON S. BRADLEY

OPERATING in the United States today is the most extensive system of intelligence ever devised for military use: the aircraft warning network. Upon this system, operated by military personnel and many thousands of civilian volunteers, depends in no small part the defense of this country against attack by air.

This article is, in general, an account of how the aircraft warning system operates. More particularly, it is an explanation of the importance of telephone communication facilities in warding off or defeating an attempted attack through the air. It is written now in order that every telephone worker in the land may have personal satisfaction in the knowledge that the industry of which he or she is a member is contributing, zealously and effectively, not only to the prosecution of the war but specifically to the protection of our shores against aerial assault: assault which may come at any moment on stealthy wings.

Before describing the role of the telephone, however, a brief explanation of the organization of our Army air forces may help to make the picture clear.

All combat units of the U. S. Army Air Forces stationed in the United States form what is designated as the Air Force Combat Command. This is organized into four Air Forces: the First, the Second, the Third, and the Fourth Air Force. Each operates in an area which represents approximately one quarter of continental United States: the north-east, north-west, south-east, and south-west. The Air Force in each of these four areas is composed of three combat elements: the Bomber Command, the Air Support Command, and the Interceptor Command. There is also a Service Command, charged with logistical arrangements.

The Bomber Commands are offensive striking forces, their function entirely aggressive.

The Support Commands coöperate closely with ground combat forces, and are the air partners of the team which, with mechanized ground units, has proved so effective abroad.

The Interceptor Commands, coordinating with the Anti-aircraft Artillery Corps, are responsible for the defense of this country against attack through the air. This they ac-

GUARDING OUR SHORES
Interceptor-pursuit aircraft in flight along the coast

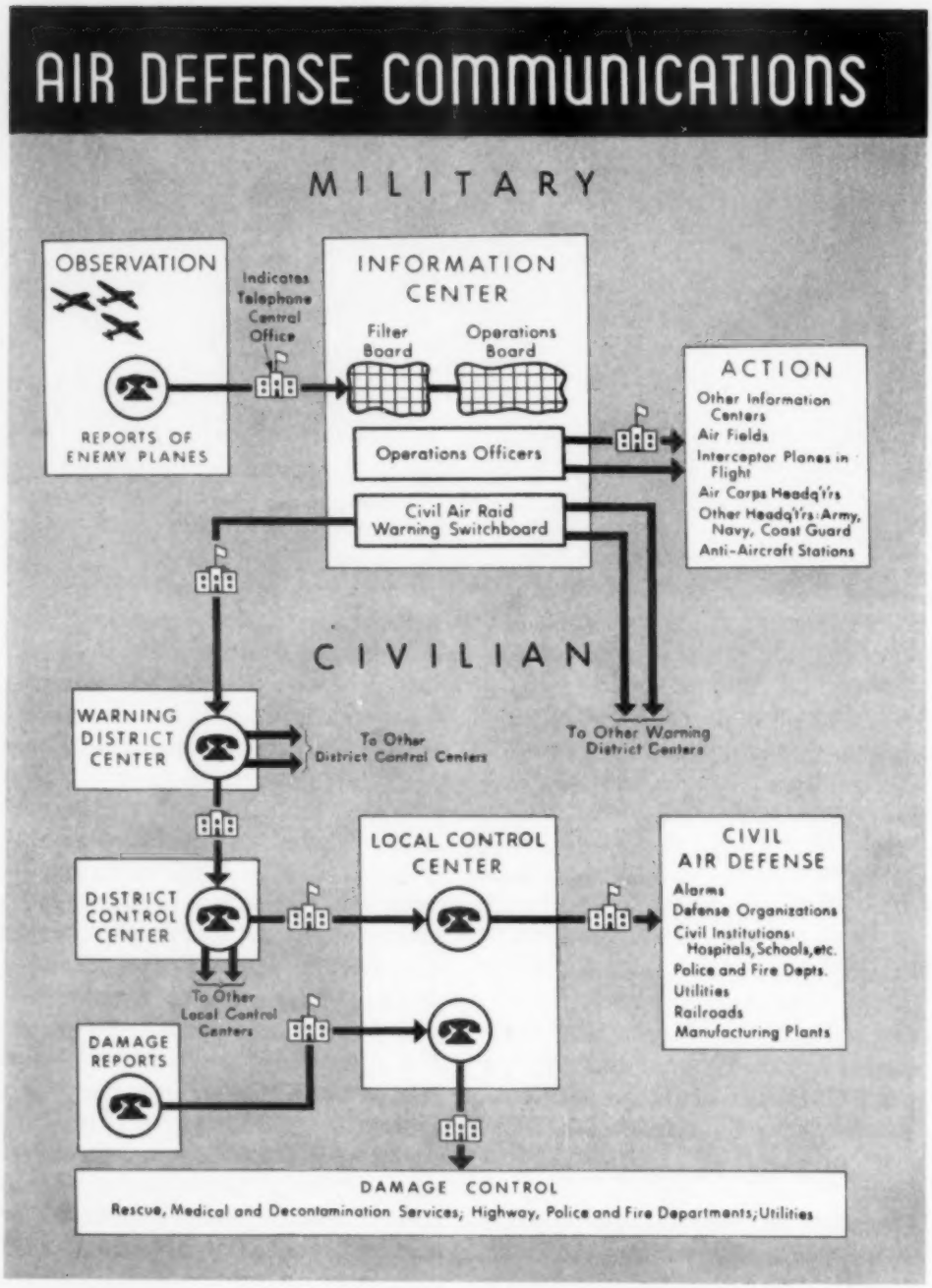
complish by destroying hostile aircraft in the air and by limiting their effectiveness by forcing them to high altitudes or away from their objectives. The means employed are, of course, interceptor pursuit squadrons and anti-aircraft artillery. They are also responsible for giving air raid warnings to civilian authorities and for ordering blackouts.

It is with the Interceptor Commands, and their use of and their coordination with and by the telephone, that the following pages deal.

How the System Works

DEFENSE against enemy air attack begins with the warning network. Radio locators are indispensable in detecting the approach of aircraft from the sea and in locating airplanes in the air. Over land, there is a vast system of civilian observation posts which swiftly report any planes, over the existing network of commercial telephone lines, to Army "filter centers." There the telephoned reports are evaluated, and the "filtered" reports are passed on to information centers, where the course of approaching aircraft is plotted, much as a yachtsman lays out on a navigation chart the course for his day's run. The Control Officer, from the information thus visually before him, takes appropriate measures to meet the situation thus presented: orders the necessary pursuit planes into the air and gives them the course to follow to intercept the enemy; perhaps calls into action anti-aircraft batteries; orders air raid warnings to areas likely to be endangered.

That is a quick look at the general



"TELEPHONE LINES AND AIR DEFENSE"

Only the upper portion of this diagram represents military activity. The lower part shows how the telephone serves Civilian Defense as well

scheme. It has been brought into existence because, instead of necessitating a constant patrol in the air, it is an effective method of interception while conserving the air forces available.

THIS plan of air defense was not devised over night. The idea of the civilian ground observer system was conceived a decade ago, and has been tried out, with the coöperation of the telephone companies, in successive maneuvers since its inception. Early experiments were crude, but each test brought improvements and refinements.* Today, upon the ground observer system depends in large part the efficacy of the Interceptor Commands which, day and night, are guarding our shores.

The system parallels in many respects—although with important differences—the air defense which, by the outbreak of the war in Europe, England had brought to a high degree of efficiency.

The interception system has several advantages.

It permits pursuit squadrons to operate from "ground alert"—in readiness to take the air against definitely located targets only. Estimates are that each plane on ground alert is the equivalent of 16 on patrol missions.

The system enables the formation leader to devote himself to combat action, since navigation and direction are done for him on the ground and sent to him by radio telephone up to the moment of contact with the enemy force.

The system also makes it possible to give adequate air-raid warnings to Civilian Defense authorities in time to permit them to take whatever measures the situation calls for.

The Aircraft Warning Network

LAND area of continental United States comprises 2,977,128 square miles. All of it, except for certain inland areas in the west, has been ruled off, on small sectional maps, into units one mile square. In each unit has been placed a symbol indicating the presence or absence of a telephone in that area. Telephones of the Coast Guard, Forestry Service, and similar agencies have been indicated. The telephone companies, Bell and independent, did that job, and turned the maps over to the Air Corps' four Interceptor Commands.

That was the start of the present ground observer network. On these maps, starting with an indicated telephone, Air Force officers laid circular templates scaled to an eight-mile diameter, and drew overlapping circles. At some point within each of these circles an observation post was carefully selected and a trustworthy citizen appointed chief observer. To obtain this enormous organization, aid of the Office of Civilian Defense, State Defense Councils, and the American Legion was enlisted. Each chief observer appointed his deputy observers, and obtained enough volunteer observers to insure constant coverage of the post—24 hours a day, seven days a week.

So, day and night, those observation posts which have been activated by the Army are manned by these patriotic civilian volunteers. Each of these

* See "A War Game Test of Telephone Service," BELL TELEPHONE QUARTERLY, January, 1939; and "Another War Game Test of Bell System Services," QUARTERLY, July, 1940.

OBSERVERS ON DUTY

Day and night, at authorized observation posts in city, town, and country, thousands of civilian volunteers peer into the sky and report airplanes seen or heard

thousands of posts has its code name; each observer has his instructions—or hers, for many women are among the watchers.

An observer at an authorized observation post, seeing or hearing an airplane, or several, goes to the telephone, says to the operator "Army Flash," gives the telephone number of his post—and initiates a train of events which are astounding both in their complexity and in the speed with which they are executed. Speed is of the essence, since the flight observed may be hostile aircraft approaching an objective at hundreds of miles an hour. And so carefully coördinated are all the elements involved in defense against air attack that in operating today they exhibit in high degree the team-work which makes the system effective.

THE telephone operator, receiving the "Army Flash" call (and screening out any such call from an unauthorized telephone), connects the observer, either directly or through her toll center, over regular commercial circuits to the regional Interceptor Command filter board terminating at a point on the filter board corresponding with the observer's own location. The value of this arrangement will be apparent from a description of operations at the filter board.

The filter board, near a city selected because of its tactical location and its telephone facilities, is a very large map of the area it covers, so mounted that it becomes in effect a table. It is marked off into squares designated by code names and numbers. These codes correspond with those of the observation posts in the area. Around

the map sit the plotters: all civilians, all volunteers. To them come the calls from observation posts, each call routed directly to the plotter nearest the mapped location of the post.

Receiving a signal light and an "alert" tone at her position, indicating a "flash" call, a plotter, equipped with a telephone operator's set, answers "Army, go ahead, please," and receives the report from the observer at his post.

The observer reports only non-technical facts, as instructed by the Army: number of planes seen or heard; whether single-, bi-, or multi-motored; apparent altitude; distance from the observation post; and direction of flight.

The plotter adjusts a marker to represent the information just given her, and places it on the map at the proper coördinate location of the reporting observation post, pointing in the reported direction of flight. This is accomplished in a matter of seconds, and the plotter is then ready at once to receive a call from another observation post.

This operation, it must be understood, takes place many times in rapid succession as one observation post after another reports—since the speed of planes is great and observers are located only a few miles apart. It takes but a moment for the markers on the map to make a definite line. Also, reports of a flight from successive observation posts corroborate each other, and thus of themselves rule out an occasional discrepancy on any one report.

THE markers, having so swiftly become a line, are now as swiftly evaluated by a "filterer," who places on a small stand nearby cards describing the observed flight, and replaces the markers with arrows indicating direction. To show the speed of the flight, the color of the arrows is alternated at regularly timed intervals.

FLASH MESSAGE FORM

Call your telephone central and say: "ARMY FLASH _____ (Gives your phone number)"
Central will connect you with an Army Information Center.
When you hear: "ARMY, GO AHEAD PLEASE", you say: "FLASH"
and continue message you have checked on form below, in the order indicated:

1	2	3	4	5	6	7	8
NUMBER OF AIRPLANES	TYPE OF AIRPLANES	ALTITUDE OF AIRPLANES	WERE AIRPLANES SEEN OR HEARD?	YOUR OBSERVATION POST CODE NAME	DIRECTION OF AIRPLANES FROM O. P.	DISTANCE OF AIRPLANES FROM O. P.	AIRPLANES HEADED TOWARD
(Number)	SINGLE-MOTOR	VERY LOW	SEEN		NW N NE W E SW S SE	(Miles)	NW N NE W E SW S SE
FEW	BIMOTOR	LOW			If airplanes were directly over O. P. cover columns 6 and 7 by reporting: "OVERHEAD"		Omit if it will cause delay in report.
MANY	MULTI-MOTOR	HIGH	HEARD				
		VERY HIGH					

RPB—7-2-41—3,000,000

OBSERVER'S REPORT FORM

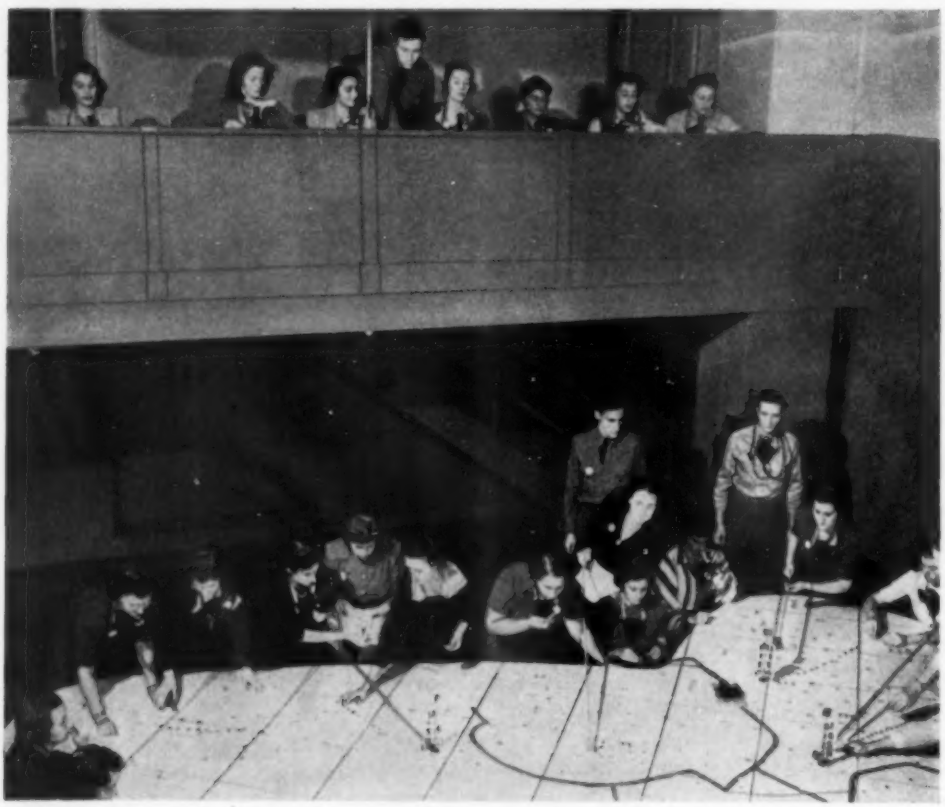
Information about aircraft seen or heard is telephoned in this order to "plotters" at the designated "filter centers"

The information about each airplane flight in a filter area, having been thus evaluated or "filtered," is now ready to be transmitted instantly over private telephone lines to an Army information center.

THE heart of the aircraft warning system is the information center. It is here that decisions are made, action is initiated.

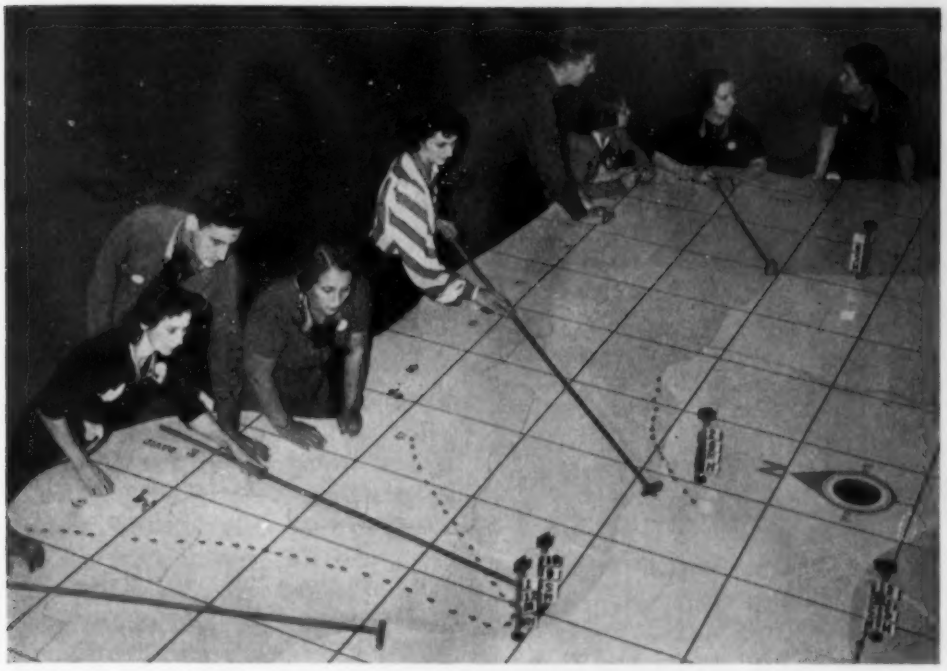
Here is the operations board for the particular defense region. Like the filter board, but larger, it includes all the filter areas of the region. Here, too, plotters place their symbols; but now they are duplicates of the evaluated information received moment by moment from tellers at each filter board in the region.

In the same room are the seaward board, on which all flights approaching from the sea are plotted; and the status board, on which are shown the availability, position, and condition of pursuit squadrons in the region.



AN ARMY FILTER BOARD

Plotters receiving reports of aircraft from civilian observation posts place markers on the map to represent the information given. As markers from successive reports form a line, the facts they reveal are evaluated or "filtered." On the balcony are tellers, who pass the filtered information by telephone to other plotters at an operations board. Women in all these posts are civilian volunteers



A CORNER OF AN OPERATIONS BOARD

Evaluated information from filter centers of a defense region is reproduced on such a map at an Army Information Center, where the Controller, on a balcony overlooking the room, is enabled to take appropriate action

Organization at the Army Information Center

ON a balcony overlooking these three boards sit the men who decide, and the men who help them. Contact among them, even between those who sit side by side, is by telephone.

First comes identification of the flight, from location and direction—if it can be identified. On the balcony, with this responsibility, are representatives—liaison officers—of the Army, the Navy, and the Civil Aeronautics Administration.

On the balcony is the Controller. He is, or acts for, the Commanding Officer of the region. It is he who orders into the air, from the most logical field in the region, pursuit of sufficient strength to effect interception of an enemy flight—of which more in a moment.

Acting as liaison officers also, and likewise on the balcony, are other important individuals:

The Anti-Aircraft Officer notifies the anti-aircraft artillery, putting these forces on the alert.

Radio Officers control various channels, including those with planes in flight.

The CAA representative can order all civilian planes grounded.

The Federal Communications Commission representative can silence broadcasting stations when and where necessary.

The Civil Air Raid Warning Of-

ON THE BALCONY

Instant telephone communication among the officers at an Army Information Center and to points outside is available through equipment such as is shown here

ficer notifies designated civilian district warning centers of the approach of enemy planes, transmits the "all clear," and issues the Interceptor Commander's orders for black-outs. With the giving of such warnings, the responsibility of the Air Force for local civilian defense ceases, since the kind and extent of passive defense measures in any community are matters to be handled by local civilian authorities.

ONCE the Controller orders pursuit planes from ground alert into the air, he immediately turns over to an Intercept Officer the navigation for and direction of those planes in flight. This officer, in a nearby room with assistants, calculates the most effective point of interception. He knows the speed, rate of climb, and other characteristics of the pursuit planes, and is in possession of information about weather conditions throughout the region. He is informed of the situation as it develops on the filter map with respect to the particular mission he is directing. Constantly in touch by radio with the pursuit flight, perhaps through successive ground stations, the Intercept Officer guides the planes to the point of contact with the enemy. When the Flight Commander tells him, in a single word, that contact with the enemy has been made, the Intercept Officer relinquishes control. In combat, the Flight Commander is on his own—although he can resume radio communication with the information center at any moment.

Just as the operations board at a regional information center duplicates and combines the evaluated information from several filter boards, so does a command post picture for the Commanding General of an Interceptor Command the situation in an entire Air Force area. Here he can observe and oversee all the activities of his command. He is, therefore, in position to dispose of his forces to meet any situation which may arise.

This account of the operation of the interception system, incomplete though it is, should confirm the remark made on a preceding page about team-work. Bearing out the accompanying statement about speed is the fact that it has taken you, the reader, longer to progress this far than would be required for the dispatch of pursuit planes on a mission following the receipt at a filter board of the first "flash" messages from the observation posts which start the process here described.

THIS has been, necessarily, a generalized picture. Nothing has been said here, for obvious reasons, about precautions in effect nor the speed with which operations can be resumed if

any vital element in the system should be damaged. It should perhaps be pointed out, too, lest this report seem unrealistic, that no method of interception can rout or bring down, every time, every plane of an enemy formation. Some may escape attack and complete a mission; particularly, as the experience of England still proves, in night assaults.

To the people of this country it should be heartening reassurance, none the less, to know that around them is spread the protection of the aircraft warning network. Watching over them, on behalf of the Interceptor Commands, are those thousands upon thousands of volunteers who, motivated wholly by patriotism, are contributing their long hours at observation posts and filter boards and information centers.

In charge of the whole system are Army Air, Artillery, and Signal Corps officers who have devised and adapted and tested and improved and now operate it: cool, keen, capable men, aware of the ever-present danger of attack by air, sensible of their grave responsibility to protect the nation and its citizens. Practical and efficient they are, too; and the Bell System's contribution to this particular phase of military defense has been made the more smoothly and effectively because they have been always receptive to suggestions which may improve the technical operation of the system over which they have charge.

The Telephone's Part

ALTHOUGH little has been said in detail about the use of the telephone in the system described, it must be evident that every operation, from the reports of airplanes seen by civilian observers to the ordering of pursuit into the air, is keyed to and carried out by telephone. And even the pursuit flight is controlled by Army radio telephone sets connected by telephone circuits to information centers.

Fundamental to all is the use of existing commercial telephone lines, both of the Bell System and of independent telephone companies, made possible because the United States is served, as is no other country, by a network of telephone lines not only interconnecting cities and towns and hamlets but reaching out into almost every countryside. "Flash" calls from observation posts, using regular commercial telephone lines, get absolute right of way, of course. Where certain telephone and teletypewriter circuits may be required for the use of the Air Forces exclusively, these are provided in most cases from available lines. Even the intricate and vitally

MORE TELEPHONE EQUIPMENT

Since an Interceptor Command's operations are executed in terms of seconds, coördination of activities by telephone is of primary importance

TELETYPEWRITER INSTALLATION FOR AN INTERCEPTOR COMMAND

Duplicating telephone circuits to a considerable extent, teletypewriters are used for communication with other points on routine matters or when messages of record are desired—as well as providing alternate routes in case of need

important intercommunicating systems by which coördination is attained at filter and information centers is put together out of standard parts, with a minimum of special equipment. The use of standard equipment—although specially arranged—expedites installation, and minimizes maintenance problems which might result from the use of specially designed facilities.

The aircraft warning system, as it exists today, might almost be said to be a joint achievement of the Army Air Force Interceptor Commands and the Bell System. The leadership is the Army's, obviously. Working with the Interceptor Commands, executing and also contributing during trials, tests, and maneuvers, have been the Bell Telephone Laboratories, which have designed and adapted circuits and equipment for special purposes; the Western Electric Company, which makes what the Laboratories design; the System's operating telephone companies, and independent telephone companies as well, which train their operating personnel and make necessary arrangements of the physical facilities; the Long Lines Department, which provides and assigns the intercity circuits and also must train those concerned with their use for such purposes; and the staff of the A. T. and T. Company, by whom the System's obligation in its broad aspect is correlated.

AN AIR RAID WARNING SWITCHBOARD

Through switchboard positions such as that shown in the foreground, the C. A. R. W. officer at each Army Information Center notifies designated civilian district warning centers of the approach of enemy planes. Note that there is a group of four jacks for each warning center: three to report differing degrees of danger, and the fourth to transmit the "all clear"

"The Determining Factor"

To summarize and conclude this discussion of the aircraft warning system, it is perhaps appropriate to quote from a broadcast made from an Interceptor Command information center by a military commentator not long ago:

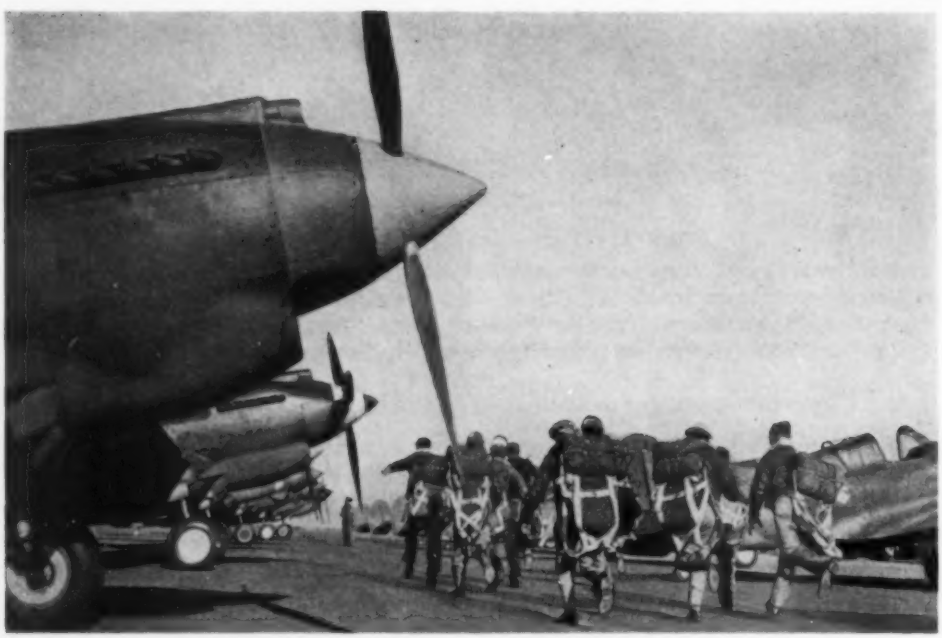
"This is essentially the same warning and interception system that the British have used in interdicting large sections of their island to enemy bombers. The systems were developed independently, and we are adapting British methods to our own use, while we pass on to them whatever we have discovered that they don't already know.

"The difference between our system and the British is this: England has high-quality telephone service, but there are relatively fewer telephones. That means that there are blank spaces that aren't covered by observers.

"That's not the case with us—we can have more observers because we have the finest telephone service and equipment in the world, all concentrated under one company *; a company that has been so enthusiastically

* This reference is obviously to the function of the A. T. and T. Company in coördinating, at the Army's request, the activities of the Bell System companies and the country's several thousand independent telephone companies to provide service for the aircraft warning network.—ED.

helpful in coöperating with the Army that it can be said with assurance that it couldn't have been done without the telephone company. They have developed special equipment; their engineers have worked with the Army over long periods; they have designed and built information centers and lent their experts to teach people how to run them; they have done, are doing, a magnificent job. However, the essential point about this whole ingenious system is so sound—proved so sound in battle—that it may well be the determining factor that wins wars."



ON THEIR WAY

These pilots of interceptor-pursuit planes have been ordered into the air on a mission

"FREQUENTLY REPRINTED DIRECTORIES" FOR THE INFORMATION SERVICE

Special Printings of the Customer Telephone Book, Supplemented by Other Records, Are a Recent Development Permitting a Faster and More Accurate Service on Calls to "Information"

By JEROME D. TOWE

THE progress made by the Bell System in providing customers with an increasingly satisfactory and pleasing service on calls to "Information" was reviewed in a recent issue of this MAGAZINE.* In emphasizing the importance of complete and easily usable records for the use of Information operators in handling calls, reference was made to a relatively new development known as the "frequently reprinted directory," which has contributed substantially to the improvement of Information service in large and medium-sized cities. These Information directories are brought up to date and completely reprinted at frequent intervals, usually every two weeks, and provide operators with a high proportion of all current listings in one convenient volume. New and changed listings for the brief period between reprints are covered in a supplemental printed list known as the "daily addendum."

While alphabetical Information directories are in most cases produced as a by-product of the regular customer directory, the frequency of reprint and the production speed required present an entirely different compilation and printing problem.

In the case of a typical large city, the customer directory is issued at intervals of from six to nine months, and requires over a month for printing and delivery. The alphabetical Information directory for that same city, on the other hand, is completely reprinted every two weeks, and the time between the close of copy and delivery to Information centers must not exceed two or three days! Somewhat similar speed requirements apply to the production of street address directories (in which the listings are arranged by street number under the proper street name) in cities where such records are provided on a frequently reprinted basis to supplement the alphabetical records.

To illustrate the service advantages gained with frequently reprinted directories, it might be well to begin by describing other types of Information records.

* "Providing the Information Service," August, 1941.

Information Records

IN many cities, particularly the larger ones, the alphabetical records consisted of three separate reference sources: 1), the regular customer directory, normally reprinted at intervals of six months or longer; 2), a cumulative main addendum for new and changed listings, brought up to date and reprinted at intervals of from two to eight weeks; and 3), a cumulative addendum reprinted daily and covering the period between reprints of the main addendum.

In a few medium-sized cities, all new and changed listings occurring between directory issues were transcribed to visible index strips and placed in rotary file frames which were used in place of the two printed addenda mentioned above.

In certain other cities, the complete customer directory was transcribed into visible index listings and placed in rotary file frames. This provided one complete alphabetical record which could be kept up to date daily, although the record was divided for capacity reasons into three, four or five rotary files.

Somewhat similar arrangements applied to street address records where they were used, although addenda for book records of this type were not provided more frequently than every two weeks.

In cities using alphabetical records consisting of the customer directory plus printed or rotary file addenda, it was necessary, in order to avoid giving out incorrect numbers, for the operator to consult the addenda first to check the latest information, since a substantial proportion of telephone numbers are changed during a directory period. While this check obviously was necessary, it was found that more than half of the calls to Information concerned listings appearing correctly in the customer directory. This resulted in a high proportion of calls requiring reference to two or three records before the desired number was found. Under this arrangement, the operator work time per call was relatively high; in other words, service to the customer was delayed.

While complete rotary files provided only one record to search, there were several disadvantages associated with these records in the larger places. The amount of space required by the volume of listing information precluded their use in many cities. Daily maintenance of listing changes consumed much time. As the volume of Information calls increased, thereby necessitating more operators, additional sets of records had to be provided and maintained.

UNDER the frequently reprinted directory arrangement, new directories for the various cities are usually printed every two weeks—although the interval may vary somewhat, depending on local conditions. While a printed cumulative daily addendum is provided under this plan, the addendum period is so shortened that it is practicable for operators to consult the main Information directory first on almost all calls, with reference to the second record—the addendum—on only a few calls.

It is interesting to note that, in cities formerly using book records, the additional cost of the frequently reprinted directories usually has been

A LISTING SLUG

On the upper edge may be seen the type characters, which are raised and in reverse

more than offset by savings in operating cost. This is attributable to the shorter work time per call, which results from the higher proportion of calls requiring only one record reference. The increased speed of handling calls has made it possible in some cities to defer for some time the provision of additional Information positions and records. Also, the compactness of the new records has facilitated the design of improved desk positions more conveniently arranged and requiring less floor space.

In addition to the faster Information service made possible by the new records, better service has resulted from the increased accuracy of the new records.

The favorable experience from the service standpoint with frequently reprinted directories as information records, and the reasonable over-all cost, have resulted in the extension of the plan to practically all of the larger and a number of the medium-sized cities in the Bell System. Information records for these cities naturally present considerably more of a problem than in the smaller places because of the amount of listing information required, the larger number of operators to be provided with records, and the volume of listing changes.

Printing Problems

BEFORE describing the various steps in the development of present-day production methods for frequently reprinted directories, it might be helpful to outline briefly the printing methods generally used for the large-city directories distributed to customers.

Customers' listings are set on typesetting machines which have keyboards somewhat similar to a type-

writer keyboard. As the keys corresponding to the type characters in the listing are depressed, individual type molds, called matrices, form a mold for the entire listing, into which hot metal pours. The product of this operation is a bar of metal with raised type characters on its printing edge, called a listing slug. Listing slugs are more easily handled than single type, and errors resulting from the dropping out of single characters are entirely prevented.

The type for each directory, in the form of listing slugs, is kept standing from issue to issue, revisions being made by inserting new slugs in proper position for new and changed listings and removing the slugs for discontinued listings. Before printing, the slugs are assembled in pages as they are to appear in the new directory. The directories are printed on high-speed rotary presses similar to those used in printing large-edition newspapers. As a necessary part of printing operations of this kind involving large press-runs, plate reproductions of the type pages are made which are curved to fit on the cylinders of the press, so that the printing is done from the plates rather than the type.

Some idea of the size of the printing job presented in producing frequently reprinted directories is indicated by the fact that the largest directory handled on this basis contains almost 800,000 listings, comprising about 1300 pages. In most cases the printing schedules for these directories provide for complete reprinting within two or three days, generally over a week-end. While the number of copies required for Information purposes is, of course, relatively small compared with the number of customer directories printed, each reprint requires type changes in practically all pages, making necessary a complete printing operation for the entire directory.

Two Sizes of Books

In the early study given to the page and column arrangements of frequently reprinted directories, it was recognized that the page size of the regular directory was not a controlling factor in determining the most suitable page size for the Information record. Accordingly, a five-column page make-up was adopted where the customer directory was on the four-column arrangement, as in most of the large cities, and a four-column make-up was used where the customer directory was on a three-column basis. This resulted in a larger page size for the Information directory, but reduced the number of pages considerably, with resultant savings in printing expense and increased printing speed. From the standpoint of ease of use as Information records, the larger page size is considered more desirable, as the resulting smaller number of pages facilitates reference.

In the preliminary consideration given to methods of printing Information directories, it was obvious that the production speed required made it essential that these directories be printed directly from type, eliminating the intermediate step of plate making. Consideration was given to the possibility of printing the alphabetical Information directory from the same set of type used for the customer directory. Tests indicated, however, that the frequency of handling and

TYPE-SETTING MACHINES

The intricate mechanisms in this group, which set customers' individual listings, are equipped to cast hard-metal listing slugs

normal wear in printing would impair the clarity of the type when used for making plates for printing the customer directory. Accordingly, the plan adopted for the first alphabetical Information directories provided for the use of an additional set of listing slugs, which was maintained independently of the type used for the regular customer directory. This arrangement, while considered satisfactory at the time, required considerable duplication of operations on the part of the telephone company in maintaining printer's listing copy, and on the part of the printer in setting up and handling two complete sets of listing slugs.

Development of Hard Metal Type

IN the original consideration of the problem, it had been recognized that the use of one set of listing slugs for both the Information directory and the regular directory would be an economy and would speed up the production of the regular directory, since the type would be kept up to date for Information record purposes. The problem here, however, was that regular type metal is relatively soft and, as previously mentioned, would be subject to considerable wear if used for printing Information records. Ordinary type metal used for listing slugs is about 85 per cent lead, 11 per cent antimony, and 4 per cent tin,

LOCKING UP

These eight pages of listing slugs are being made up in four-column pages for the production of an Information directory for use in a city where the customer book is three columns wide.

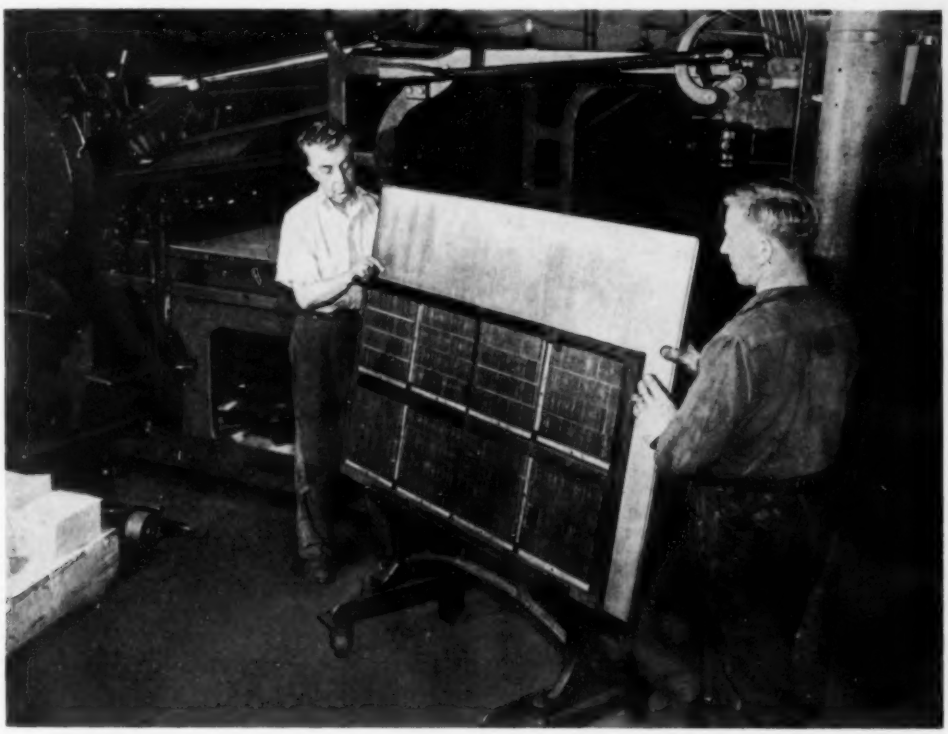
and tends to scratch and show other imperfections when handled frequently.

The idea was advanced that the use of a harder metal in the casting of listing slugs might permit using one set of type for all alphabetical records without impairing the clarity of the type. Experiments were made with a number of metals available commercially, but it was several years before a suitable metal alloy of the required hardness and other essential characteristics was developed. In the metal alloy finally adopted, the lead content was materially reduced, the amount of tin and antimony increased, and very small quantities of copper and cadmium added.

THE use of one set of type for printing both the regular customer directory and the alphabetical Information directory made it desirable that both directories be handled by the same printer, in order to avoid divided responsibility for the printing job. Also, in order to obtain the full benefit of the plan, it was highly desirable that the same printer handle the daily addendum, which would be printed from the same type as the other alphabetical records. Distance between the directory office of the telephone company and the regular directory printer made it impracticable for some companies to forward copy for the daily addendum by messenger. Accordingly, in order to insure the printing savings and other advantages of using one set of type for all alphabetical records, arrangements were made for transmitting copy to the printer by teletypewriter.

In addition to being faster than messenger service, use of the teletypewriter made it feasible to forward copy several times a day, with resulting improvement in the flow of work to the printer. This latter advantage is important, particularly at periods of peak service-order activity, since the printing of the daily addendum for cities located several hundred miles away is a carefully timed night-shift operation with a definite dead-line. To assure delivery of the addendum before eight o'clock the following morning, arrangements are made for special mail or express handling on a night train arriving at the distant city at an early hour and for regularly scheduled pick-up and delivery to the Information center.

One set of hard metal type used for the daily addendum, the alphabetical Information directory, and the regular customer directory, is now recognized as the most efficient plan where the Information records and the regular directory can be handled by the same printer. Under this arrangement, the listing slugs set up originally for the daily addendum are transferred to the standing type for the Information directory when a new issue of the latter record is to be printed. The Information directory in most cases is printed over a week-end, since the accumulated type for



READY FOR THE PRESS

The rolling table tilts to a horizontal position at the exact height of the press bed, minimizing the lifting of the type form

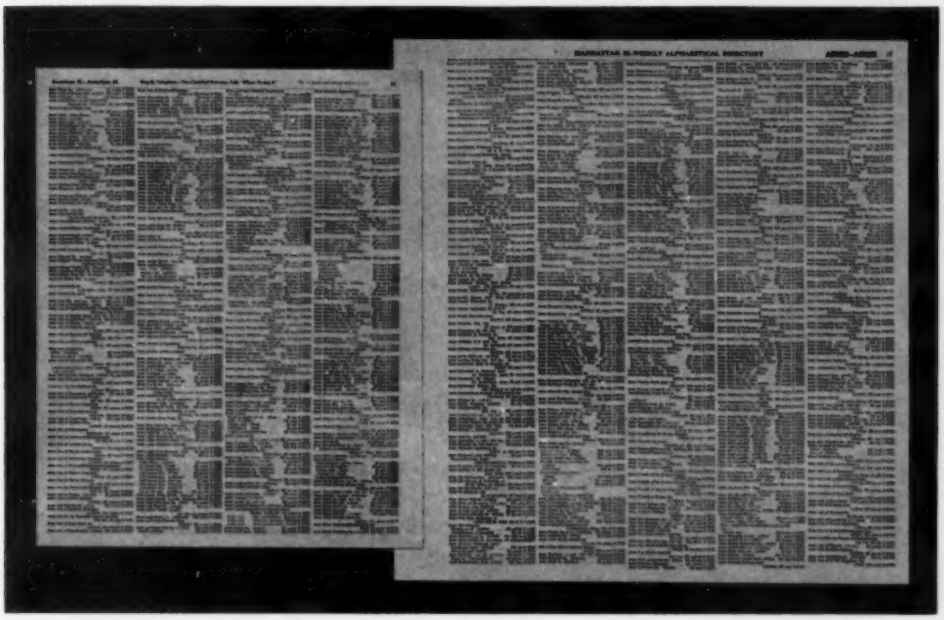
the daily addendum ordinarily can be used during that period without interfering with the production of the daily addendum. In printing the regular customer directory, the standing type for the Information directory is reformed into standard-size pages preliminary to making the plates from which the directory is printed. After the regular directory has been printed, the type is again arranged in Information directory page style and is ready for the next issue of that directory.

Mechanical Improvements

THERE is, of course, considerably more handling of the standing type in the printing of Information directories than in the case of regular directories. In connection with each reprint the type must be removed from storage racks, listing slugs added and removed, the type pages locked up and placed on the press, and the type finally moved back to the storage racks. Type is heavy—four pages weighing some 150 pounds—so that it is important to keep the amount of handling and lifting to a minimum. A number of interesting developments were introduced which considerably reduce the handling time. While the problems in the various printing plants naturally required individual solution because of differences in printing methods, plant lay-out, and storage facilities, operations generally were speeded up and efficiency improved by the use of specially designed type storage racks, type trays, metal frames for holding the type in page form, transfer tables mounted on rollers, and similar improvements.

The introduction of hard metal type has advantages for regular directory work as well as for the Information service. Since only one set of type is used, the telephone company maintains only one set of printer's listing copy. The company is able to make current checks on the accuracy of listings inserted in the Information records, as a result of proof-reading in the directory office and use of the records by Information operators, and to make any necessary corrections before the listings appear in the regular customer directory. While the number of such errors discovered is relatively small, due to the high standards of compilation and printing accuracy, the result of these checks has been to reduce the already low level of directory errors by as much as 25 per cent in some cases. Another advantage has been in a reduction in time, between the close of copy of the regular directory and delivery to customers, of a week or more for some directories—because the type is up to date at directory closing except for last-minute changes. With this reduction in directory production time, a customer receives a more up-to-date directory, and this tends to reduce the load at "Information" earlier than would otherwise be the case.

ALTHOUGH the frequently reprinted directory plan originally was restricted to the larger cities, developments in production methods have resulted in bringing the cost of the plan for medium sized cities down to a point where it has been adopted for a number of such cities. The principal difficulty here has been the relatively



CONTRASTING PAGES

The page at the left is from a customer directory, while at the right is one from the same city's alphabetical frequently-reprinted Information directory which illustrates the large amount of listing information shown on a single page of the latter

high cost of providing printed daily addenda for these cities and the fact that in many cases the distance to the regular directory printer makes it impractical to provide overnight printing and delivery of the addendum. Equipment has been developed recently, however, which makes it feasible for the telephone company to produce the daily addendum locally on multigraph equipment at a cost sufficiently low in many cases to warrant the introduction of frequently reprinted records.

THE use of frequently reprinted directories in providing the Information service is a development about which the telephone user will probably never hear. As this article has made evident, it is only one aspect—and a somewhat technical one, at that—of giving him a quick and courteous and accurate answer to the inquiry he makes of the Information operator. But to the user, that—and every—inquiry is important. And since upon the Bell System rests the acknowledged responsibility of furnishing its customers with the best telephone service possible, whatever contributes to a more satisfactory Information service makes a contribution also to the achievement of that ideal.

ACROSS THE ROOF OF THE CONTINENT

A New Line Through the Rocky Mountains, Built to Unusually Exacting Specifications, Replaces What Was for 41 Years the Highest Regular Telephone Toll Line in the World

By STUART SHAW

THE highest regular telephone toll line in the world no longer crosses Argentine Pass, in the Rocky Mountains of Colorado, where for more than 40 years it has withstood the snows and winds a-top the Continental Divide. That line has recently been dismantled, and the altitudinous distinction apparently belongs now to a line which crosses the Andes of South America. But the old line crossing the Rockies has been superseded by a new one built last year over Loveland Pass at a somewhat lesser height.

The story of the two lines, the old and the new, is worth telling, for both are unusual construction projects; and together they write one more chapter in the tale of providing telephone service for people wherever they may be—in busy cities, on level prairies, or in the canyons and on the rocky slopes of great mountains.

The routes of early-day long distance telephone lines across the Rocky Mountains often were dictated by the location of mining camps, for it was there that the need for service lay. It was for this reason that in 1899–1900 a regular long distance line was constructed over Argentine Pass, crossing the Continental Divide in central Colorado at an altitude of 13,300 feet above sea level. This is very high—even in a state that includes within its borders 49 of the total of 64 peaks in the United States 14,000 feet or more in height.

There were many lower passes than the Argentine. Why should a telephone line have been built over this inhospitable crest, where storm and wind conditions rivaled those of the Arctic?

The answer lies in the fact that some of the richest silver mining country in the world lay along the lower reaches of both sides of the pass. Mines and mills, employing a large number of men, clung to the hillsides, and the water courses were dotted with busy camps now almost forgotten. Those interests could be served on the same pole line that carried other circuits.

And so it was that the Argentine Pass line of The Mountain States Telephone and Telegraph Company came into being. At the time it was

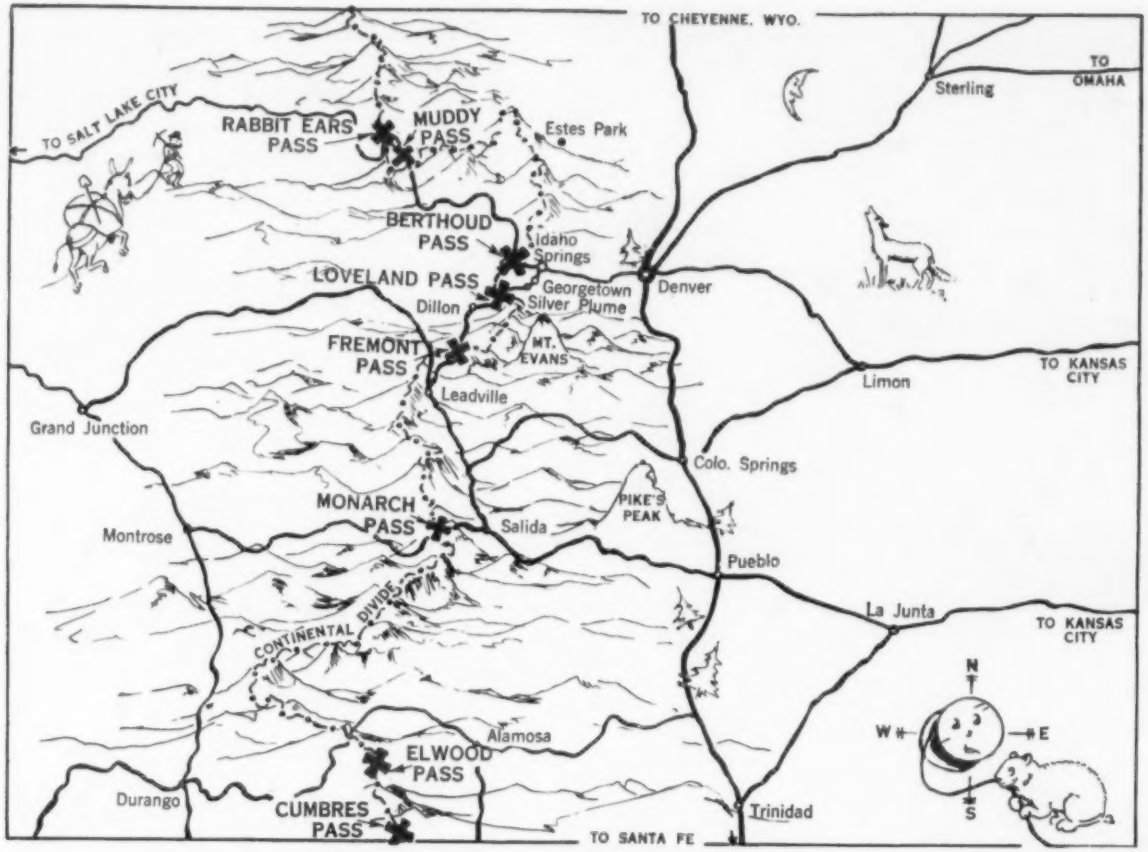
NO LONGER THE HIGHEST

These were the top fixtures of the telephone line over Argentine Pass, elevation 13,300 feet—the highest regular toll line in the world. With the construction of the line over Loveland Pass, at a lower elevation, this line was superseded, and was dismantled last year

removed from service, in the summer of 1941, it was, as far as available records show, the highest regular toll line in the world. There were single telephones at higher altitudes—as, for instance, the telephone on the summit of Pike's Peak at more than 14,000 feet—but no regular toll line connecting telephone exchanges.

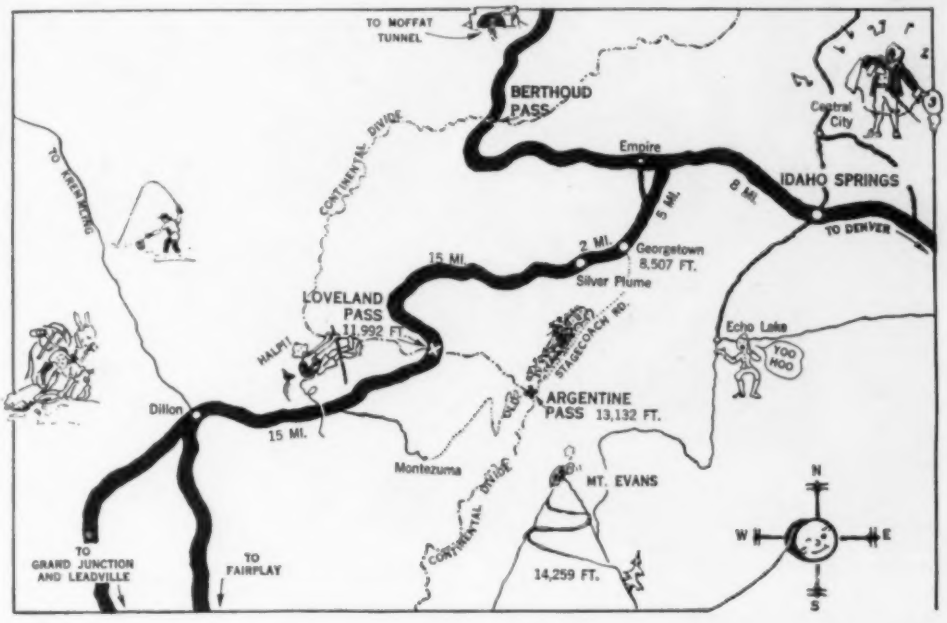
Construction of this line, connecting Denver, Central City, Idaho Springs, and Georgetown with the booming Western Slope camp of Leadville was a staggering job for both man and beast. When the high altitudes were reached, a base camp was established at timberline, with a large crew working toward the top. All materials had to be maneuvered to the summit by men and horses. Simply getting to and from work each day often meant an arduous climb of several thousand feet in the thin and brittle air of this altitude.

It had been planned to lay submarine cable in a shallow trench over the top section as a protection to the service against the vicious storms that swirled over the crest. But the snows came early in 1899, and the cable had not arrived, so a crew under Murray MacNeill, present plant extensions engineer of the Mountain States Telephone and Telegraph Company, laid insulated wire over the snow for use during that first winter. The wire



EIGHT CROSSINGS OF THE CONTINENTAL DIVIDE

This sketch-map of the State of Colorado shows the passes over which telephone lines cross the Rockies. Only important roads and towns—and local color—are included



WHERE THE NEW LINE CROSSES

This drawing includes only the area in the general vicinity of Loveland Pass and Argentine Pass. Elevations shown are for the roads, which are somewhat lower than the telephone lines

was broken on a number of occasions by snowslides and had to be repaired.

The submarine cable was laid the following summer. It served well, except that it was subject to damage from slide rock, and the mountain rats (called conies) had a taste for the jute covering of the cable. Frequent repairs were necessary. The line was extended to Grand Junction soon after 1900, and became an important route serving Western Slope points.

MAINTAINING this line always has been difficult, however, and even hazardous. Argentine Pass can be reached only by a historic old stage road that connected the mining camps of Georgetown and Leadville in the 70's. It was too steep for anything but horse or foot travel, even during the summer months. And throughout the long winter a trip on snowshoes or skis was the only answer to a case of trouble on this route.

The line was rebuilt in 1917, with open wire construction of the heaviest type yet seen in the section over the top. This proved satisfactory from a strength standpoint, and the line was in service continuously until the summer of 1941. From a transmission standpoint, however, this line had become increasingly unsatisfactory.

The conductors over the top section were steel messenger strand, to provide the needed strength. In recent years a high-tension power line had closely paralleled the telephone line over a large part of the route—another objectionable factor. Further-

IT'S A LONG WAY UP

A load of telephone poles at the summit of Loveland Pass. The new line is at the left—and higher

AERIAL TRAMWAY

Poles are being carried up a rocky mountainside above Silver Plume by means of winch lines operating from the telephone trucks in the right background. The tracks seen in the picture are for ore cars of the mine which is the location of this operation

HOLE FOR A POLE

Digging pole holes was a tough job; most of them had to be dynamited. Clearing right-of-way is progressing in the background

more, most of the poles had been in service nearly 25 years and would soon have to be very largely replaced. As a matter of immediate necessity, some of the steel strand across the top had been replaced with stranded copper about two years ago, but the greater part of the steel remained.

ALTHOUGH there still is a certain amount of silver production in the Argentine area, today many of the properties are but ghostly reminders of a past that was glorious—at least while it lasted. Obviously, the conditions under which the Argentine Pass line was built have changed considerably. What is more, the horseless carriage has come to stay—and with it a new conception of roads and transportation.

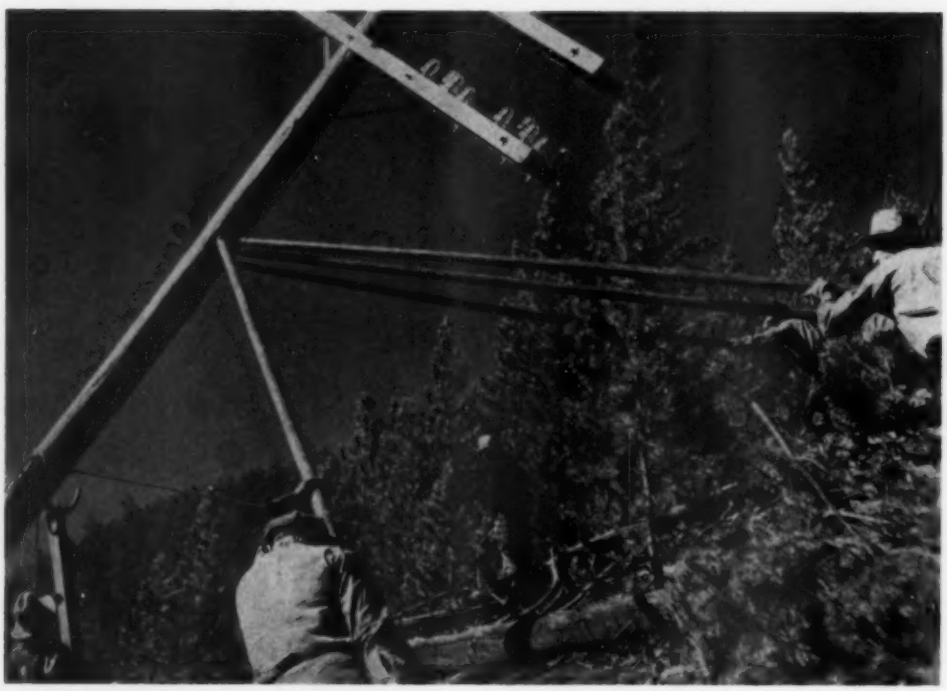
When the state of Colorado determined to build a broad, hard-surfaced highway over Loveland Pass, between Georgetown and Leadville, it became evident that this would be a far more satisfactory route for the Denver-Grand Junction toll line. Loveland Pass is about six miles north of Argentine Pass, with a gigantic mass of serrated peaks lying between, a number over 14,000 feet. It is a somewhat lower pass—12,000 feet, as compared to more than 13,000 for Argentine. The new highway would be a principal route between Denver and Western Slope points, and would

SNAKING A POLE TO ITS LOCATION

So steep and rough was the going here that horses found difficulty in staying on their feet

ATTACHING CROSS-ARMS

A drive screw is hammered home in a setting of scenic splendor



IN TIMBER WEST OF LOVELAND PASS

Snubbing rope and pole gin are typical of the precautions which resulted in a perfect safety record for the entire project

GRANDSTAND VIEW

Construction of an H-fixture on the crest of Loveland Pass

CONSTRUCTION NEAR THE SUMMIT

The crew is preparing to string the stranded copper conductors. Note the heavy construction and guying shown on the H-fixture in the center of this picture

be kept open all winter with powerful snowplows. Maintenance of the telephone line could be effected with comparative ease, for it need never be more than a few hundred yards from the road. Construction, too, would be simplified.

The decision was reached early in 1940 to build a 19-mile reroute of the line over Loveland Pass, and the highest toll line in the world was to be no more. Our information indicates that the distinction now goes to South America where a line crosses the Andes at 12,600 feet. But the Loveland Pass line remains the highest in North America.

Laying Out the Line

STUDIES of snow conditions on Loveland and other passes had been made over a period of years. The engineers sharpened their pencils to design facilities in the light of more than fifty years of experience in mountain construction. Much detailed engineering work preceded actual construction of this new section of line. Special facilities were required, to produce needed strength characteristics. A half mile section of the line across the top of the pass was designed to withstand a 70- to 75-mile-an-hour wind coupled with ice coating on the wires averaging four inches in diameter!

Two survey parties started out as early in 1940 as snow conditions would permit, working up from each side toward the top of the pass, laying out the line and specifying pole locations, sizes and so forth. The new line was to leave the old at Georgetown and rejoin it on the other side of the pass, near Dillon.

It is a fascinating country, both scenically and historically. At numerous points the route of the new line crosses the clearly discernible track of an old stage road, one that supplanted the Argentine Pass route in 1879 and set a new high in transportation at that time. Passengers in those days made the trip in a Concord stagecoach, covering the distance between Georgetown and Leadville from dawn to dark! Today it takes less than two hours.

As soon as the project was approved, orders for material were placed with the Western Electric Company. Much of this material was of a decidedly special nature.

In the meantime, ground crews started clearing the right of way and digging the pole holes. This was laborious hand work. To understand why, one need only visualize a condition, not of rocky ground, but of rocks with a little dirt between them. Even if it had been possible to get motor driven digging equipment to the right of way—which it generally was not—it could not have been used because of the character of the ground. Few holes were dug without the use of dynamite.

A RIGHT-OF-WAY had to be obtained and clearance provided for ten feet on each side of the center of the line. Except for the top section, practically the entire 19 miles had to be cleared, for the route lay through wooded country, a tangle of aspen and spruce, with a few sections of heavy timber. Coöperating with the Forest Service, much good timber was saved by careful trimming. The brush was piled for burning as soon as a sufficient

A FINISHED SECTION OF THE LINE

Note that, contrary to usual practice, the pole line is not straight—thereby avoiding low ground where the snow may drift 20 to 30 feet deep in winter

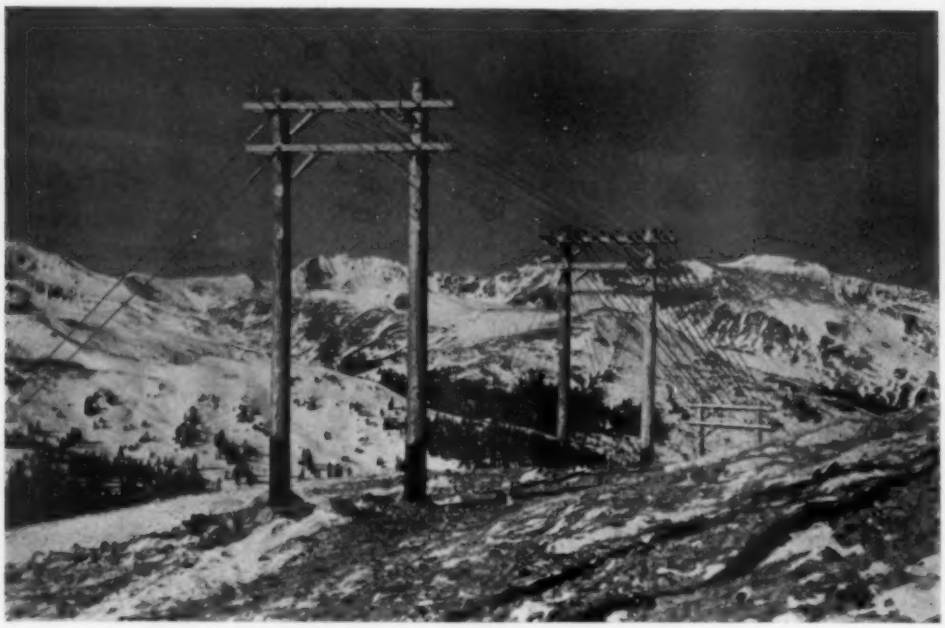
snowfall laid a protective blanket of moisture over the surrounding forest.

In general, full length treated lodgepole pine poles, native to the mountain territory, were used in building the line. The railroad was utilized from Denver as far as its terminus at Idaho Springs, but this was still 25 miles from the top of the pass and more than 4,000 feet lower in altitude. The poles and other material were hauled by truck from this point to various locations along the road near the right of way. From the road, all the material had to be either carried by the men or snaked with horses to the point where it was to be used in the line.

The poles varied between 25 and 40 feet in length, depending on the requirements of a particular location. In unloading, care had to be exercised to drop off poles of the proper length in the right locations.

There was nothing unusual about the framing and setting of the poles in the lower sections except, perhaps, that in numerous places the right of way was so steep that a crew moving from one pole location to another might climb or descend a hundred feet.

ON the Eastern Slope, just above the old mining camp of Silver Plume, the line lay across the face of rocky cliffs where even horses could not drag the poles into position. At several successive locations along these cliffs a pulley block was attached either to a large tree or to an outcropping of solid rock, about 400 feet above the road, and the winch line from the power-driven winch on the



AT THE SUMMIT

This is the line as it crosses the crest of Loveland Pass—altitude slightly more than 12,000 feet. Well illustrated is the unusually sturdy construction which is necessary to withstand the snows and gales of mountain winters

construction truck was passed through it. The resulting aerial tram was capable of transporting safely a load of some twelve or fifteen hundred pounds in the form of poles or crossarms.

Unusual Construction Features

STRENGTH is the outstanding characteristic of the two-pole H-fixture type of construction used exclusively in the half-mile section across the top of the Pass.

The poles used in the H-fixtures have approximately twice the strength of poles ordinarily used on such a line at lower altitudes. The span length is approximately 80 feet, instead of the usual 130 to 160 feet. The line is sectionalized in 300- to 400-foot sections by having the line wires dead-ended in both directions on separate crossarms, a short jumper wire being used to connect the dead-ended points of each individual line wire. This is done so that a possible failure of one section would not necessarily bring down adjoining sections.

The H-fixture pole construction at each end of the sectionalized pieces of the line is guyed at right angles to the line and also in the direction of the line with 10,000 and 16,000 pound steel strand. Intermediate side anchors are provided throughout the various sections.

Special insulators, crossarm braces, and transposition brackets are provided. It is estimated that the pole structure has about eight times normal strength. The line wires in this

top section are composed of No. 1 stranded hard drawn copper wire, with a breaking strength of 3,800 pounds. This represents about five times the strength of the ordinary 128 hard drawn copper wire.

THUS a new crossing of the Continental Divide took its place in the system of the Mountain States Telephone and Telegraph Company. It is one of eight such crossings in Colorado alone. The seven Rocky Mountain states served by the Company comprise a far flung and rugged territory that is 24 per cent of the area of the United States and includes but 3 per cent of the population. A main range of mountains divides it all the way from the Canadian border to Mexico and presents problems of telephone construction and maintenance seen nowhere else on a comparable scale in the Bell System.

BILLS FOR 13,000,000 CUSTOMERS

Charging for a Hundred Million Items Each Month Is an Extremely Complex Operation Requiring Modern Methods and Machines to Achieve Accuracy, Promptness, and Clarity

By F. RAYMOND BREWSTER

EVERYONE who operates a business on a credit basis knows the importance of accuracy and promptness in the rendering of periodic statements to his customers. Whether it be a neighborhood store or a large business, there is extra responsibility at "billing time." Every business man who strives to give good service is naturally anxious to avoid those irritating and time-consuming incidents known as errors. The Bell System, with more than 13,000,000 customers, whose services require the billing of more than 100,000,000 items each month, obviously has a problem of extraordinary complexity. These items consist mainly of charges for the installation of or change in service, and for local service and out-of-town calls. At every step along the line, from the several sources of origin of these millions of transactions to their reflection on the bills, there are numerous opportunities for mistakes.

That the System has arrived at an average of only 3.8 errors affecting the amount of the charge or credit for every 1,000 bills rendered indicates that it has approached the problem with care and thoroughness, since this average includes errors irrespective of where they originate: whether made in writing a toll charge ticket; in writing service orders and reporting the work done on the orders; in recording, computing, and accounting for service charges; in reporting and applying payments; or to any other of the many phases of operation and accounting in which errors may affect the amount of the bill.

It is not the purpose of this story to deal primarily with errors, but since the accuracy of the bills and the promptness with which they are rendered are the two most important bases for measuring the character of the job performed by all departments, in so far as their activities are reflected on the bills, it is helpful to know at the outset what sort of result is achieved.

Customers are mainly interested in receiving accurate bills. Probably not so many are particularly interested in receiving bills promptly. There is, none the less, a mutual advantage to the customer and to the telephone company in prompt billing. To the

IN AN OPERATING COMPANY'S REVENUE ACCOUNTING DEPARTMENT
Various clerical operations in connection with the preparation of tickets for billing customers' toll service are being carried on by the group of girls shown here

customer, the prompt receipt of the bill enables him more readily to check the items billed, because they are current, while regularity in the receipt of the bill leads him to expect it on a given date and assists him in planning to meet it. To the company, the principal advantage is that regularity in the delivery of bills to customers results in regularity in the pattern of payments, so that the receipts and disbursements of cash can be coordinated to fit the pattern, thereby permitting an efficient management of funds.

SOME further idea of the magnitude of the task of the Bell System in preparing telephone bills may be gained by simply stating a few facts. The bills now cover the monthly fixed charges for 19,000,000 telephones. During the year 1941 there was an increase in the System of about 1,360,000 telephones; but to produce this net increase, nearly 5,500,000 telephones were connected and more than 4,100,000 were disconnected. This movement of telephones in and out requires a vast amount of clerical work.

In the Accounting Department, each connection or disconnection requires the establishment of a new customer's account or the closing out of an account or a change in the address or in the monthly fixed charge for an existing account—all of which usually requires the computation of a fractional monthly charge during the month in which the telephone was connected or disconnected.

Each of the 13,000,000 bills issued carries the regular recurring monthly charge for service. This is the amount which the customer generally has in mind as the charge for his service and,

on the average, about half of the Bell System's customers have no other charges. However, about half the bills include charges for toll messages and for telegrams telephoned to telegraph offices for sending. The total number of such items is now averaging about 70,000,000 monthly. Other types of charges appearing on telephone bills include those for local messages in excess of a stipulated number per month when the service is on a measured basis; those for advertising in telephone directories; and adjustments due to changes in service or equipment involving revisions in rate, or to moves into areas having a different billing date.

New Taxes Present Problems

THE Revenue Act of 1941, signed by the President on September 20, 1941, introduced a number of new problems in billing and accounting for the Federal taxes on telephone service. Prior to the enactment of this law, a Federal tax was imposed only on telephone messages of 50 cents or more and only at three rates (10 cents, 15 cents, or 20 cents), which could easily be memorized by the clerks affected; on telegrams at 5 per cent, cable and radio dispatches at 10 cents each; and on leased wires, including teletypewriter exchange service, at 5 per cent. Under the new law, the tax is imposed at the rate of five cents for each 50 cents of charge or fraction for telephone messages of 25 cents and over and at 6 per cent for messages of less than 25 cents, as well as 6 per cent on local service charges; also on teletypewriter exchange service, telegrams and leased wires at 10 per cent.

The introduction of a tax schedule at different percentage rates for different services, and also at a sliding scale which produces tax charges of amounts much more diverse than the three charges previously in effect, caused some difficult problems in setting up billing procedures. It also resulted in an increase in the billing and accounting work due to the substantial increase in the number of entries of tax charges on toll tickets and bills. In addition to the Federal tax, city and state taxes must also be billed where applicable. The billing of these varied tax charges not only involves a considerable amount of work, but seriously increases the possibility of error.

The billing and accounting problems raised by the provisions for taxing telephone service under the Revenue Bill of 1941 will serve to illustrate the accounting methods service rendered to the Associated Companies of the Bell System by the centralized staff of the American Telephone and Telegraph Company. This problem, like many other activities, required close coördination of the Methods Staff of the A. T. & T. Comptroller's Department with others, in this case especially the staff of the Commercial Engineer and the General Tax Attorney. It was necessary to keep closely informed on the progress of the legislation through Congress in order to keep the methods problem abreast of the law and to develop uniform interpretations for the guidance of the field. In this case, a centralized staff made it unnecessary for each Associated Company separately to perform these services for itself. It also relieved the Internal Revenue Bureau at Washington of a multiplicity of in-

SORTING TOLL TICKETS BY TELEPHONE NUMBER

The 100-pocket racks are numbered from 0 to 99. By sorting by the last two digits of the telephone number, and then reversing the pile and sorting by the first two digits, toll tickets can be quickly arranged in the numerical order of the telephones in a given central office

quiries on questions common to all the companies.

The probability that there would be new tax problems to meet became apparent in the Spring of 1941, when the United States Treasury Department tax proposals were first mentioned and a subcommittee of the Ways and Means Committee of the House of Representatives began to consider tax legislation. It soon became evident that some form of tax on telephone service other than the one then applicable probably would be written into the new law. Each of the several proposals made was considered, and tentative plans were sketched for meeting the problems peculiar to each proposal.

Much of the billing and accounting work requires the use of office machines, some of which are of special construction. In view of the growing delays in the delivery of such equipment, the first definite action was to suggest to the Associated Companies that they place orders at once for any necessary additional mechanical equipment, and also that they consider engaging additional clerical employees who could be partially trained by the time the added tax work became a reality. They were also advised regarding certain changes that might be necessary in some of the machines in order to meet the billing requirements under the new tax bill. The Western Electric Company was also consulted regarding provision for an adequate supply of paper which

would be required for a large quantity of new toll service statements.

In July, 1941, the general basis of the new taxes was sufficiently clear to enable the staff to give the Associated Companies some preliminary information, although the specific rates of tax and the probable effective date were not known. By the end of August, the terms of the new tax bill had been reasonably settled, although not with sufficient certainty to permit of starting the chain of operations that would be required in connection with revising the billing records.

AFTER the revenue bill had passed the House and the Senate and the several amendments had been agreed to by the conference committee and lacked only the President's signature to become a law, it was considered safe to go ahead. The entire procedure had been closely followed by the Methods Staff, and constant contact had been maintained with the field, so that when the signal to proceed with the preliminary work of revising the billing records for 13,000,000 customers was given, the job got under way with little delay. The alteration of billing machines, designing and procurement of new electrotypes for the machines which print and address the bill forms, and the work of printing an initial supply of some 20,000,000 new toll service statements and other new forms was started at full speed when the bill was finally passed.

The President signed the bill on September 20; but on September 19 seventeen pages of text and twenty-two exhibits, prepared in coöperation

PREPARATION OF TOLL STATEMENTS

After individual toll tickets have been arranged in telephone-number order, the items, charges, and taxes are listed on the toll statements which accompany subscribers' bills. About seventy million such items are listed each month at the billing centers of Bell System operating companies

with the Commercial Engineer's staff, were mailed to the Associated Companies, outlining the new procedures to be followed in the preparation of customers' bills.

Rotation Billing

THE actual preparation and issuance of telephone bills is carried on by the Associated Companies of the Bell System, since it is they, of course, which provide the services for which the bills are rendered. Each company has one or more billing centers where the bills are prepared. These billing centers are known as revenue accounting offices, and are part of the Accounting Departments of the several companies.

The basic material from which the bills are prepared, such as service orders, toll tickets, etc., is received in the revenue accounting office daily from all the exchanges for which it handles the billing. It has been found most economical to centralize the preparation of bills for an entire company or state or for a large group of exchanges. This centralization provides the most efficient organization of the billing work and permits the economical use of high-capacity office machines.

Bills are issued on a "rotation billing" basis. Under this plan, the accounts of a revenue accounting office are divided into groups (usually six or ten) by exchanges or central offices, and a fixed calendar date is assigned to each group. Bills are released upon completion, with an objective of not more than six business days after date. In the first part of 1941, this objective was 95 per cent achieved. The specific release dates of bills payable at each business office are forecast at least one month in advance, so that provision can be made for the personnel requirement for the business office peak periods. Rotation billing, by distributing the total work throughout the month, makes possible the listing of all the toll service and telegram charges for the entire monthly period for each customer in a single handling, and also permits the use of toll service statements printed and perforated on a continuous roll of paper.

FOR PREPARING TOLL STATEMENTS

Such typewriters, equipped for their particular function, have capital letters only, automatic paper-handling device, counter for totaling the number of items listed, and electric carriage return

THE adoption of rotation billing makes possible the economical application of billing machines to the preparation of customers' bills, and a total of 450 such machines is now being used by all Associated Companies. These billing machines embody features not previously available in such machines, and as a result of the work of the Methods Division in coöperation with the manufacturer, they have become standard features

A BILLING MACHINE

In the rack may be seen the data from which customers' bills are prepared. Above them is the numerical keyboard, while the oblong keys at the right are the line finders which automatically move the bill form to the printed line corresponding with the charge about to be listed

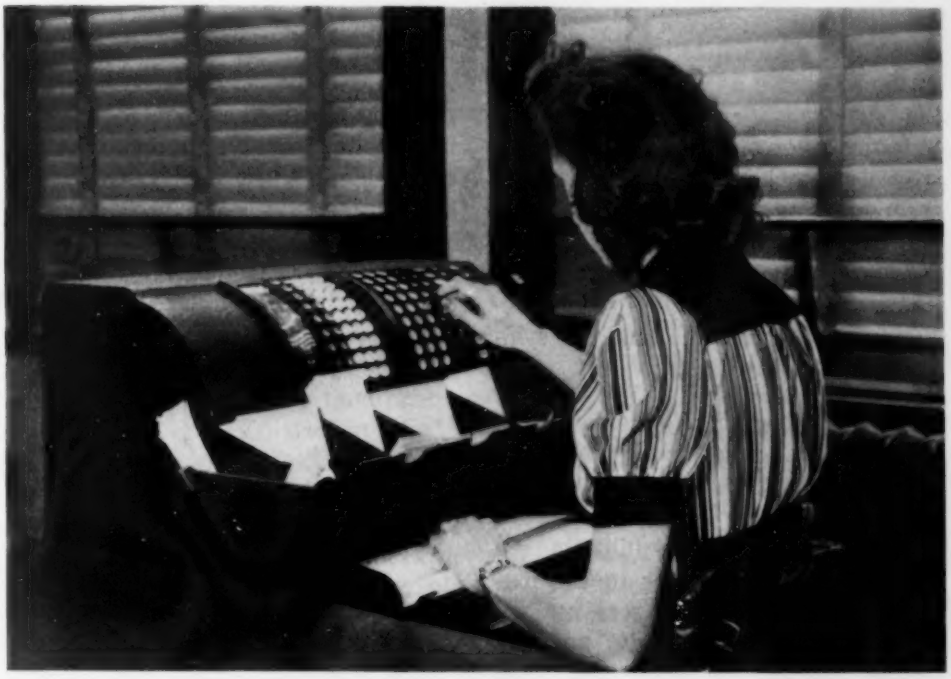
of this type of machine and made available to all who have use for them.

One of the important improvements embodied in such machines for the first time is the automatic line finder. In the type of billing machine previously used, the operator was required manually to turn the platen of the machine to the proper line for the entry of any charge other than that appearing on the first line of the bill. This not only required time, but what is more important, it was subject to inaccuracies which could be detected only by means of a visual line-by-line comparison of the completed bills with the posting media.

In the operation of the machine, the bill form is inserted and aligned against a stop on the feed table below the keyboard. The amounts of the monthly service charge and the related Federal tax, as shown by the card record of the customer's service, are set up by depressing the proper keys. The depression of the control key for the first writing line automatically injects the bill form into the machine, imprints the amount of the tax and the monthly service charge, including the tax, on the first line of the bill form and its three stubs simultaneously, stores the amount in an accumulating register for that line, and also adds the amount in a register known as a "crossfooter" which accumulates the total amounts entered on a given bill.

THE other charges to be shown on the same bill may be entered in any sequence and will be printed on the proper line of the bill and stubs by the depression of the control key associated with that line. There are usually six lines on the bill forms, and the machines have control keys for each line. Since the bill form cannot be seen by the operator during the process of its preparation, a "window" is provided in the machine case at the right-hand side below the keys, through which the operator may see the amount and the classification of the last item entered on the bill. Credit amounts are imprinted on the bills in red and are automatically subtracted from the bill total.

When the last item to be shown on



A BILLING MACHINE IN USE

The operator is inserting a bill form in the throat of the machine, where it automatically moves up to receive charges for the various services in proper order. When the "total" key is punched, that final figure is printed and the completed bill is ejected into a rack located below the operator's left hand. Bills for the Bell System's thirteen million customers include more than a hundred million items each month

the bill form has been entered, a "Total Bill" key is depressed which automatically prints the total on the bill and stubs, stores it in an accumulating register, clears the "crossfooter" ready for the next bill, and ejects and stacks the bill in a tray below the feeding table. The operation of the machines may appear to be complicated in description, but because of their automatic features, they are simple to operate and produce bills which are neat and accurate and for which the charges are proved against "control" totals before the bills are released to customers.

Double-Checking for Accuracy

THE proof of the accuracy of work is stressed at every step throughout the process of preparing bills, and if it is not secured as a by-product of some operation, it is given special attention to the extent warranted by the results being secured. The clerical and mechanical processes are planned so that, as much as possible, accuracy is effected automatically or mechanically, dependence on visual comparisons being avoided when possible.

A typical illustration of a "by-product" proof is the verification available through the comparison of

predetermined "control" billing totals with those automatically accumulated in the machines as the preparation of the bills progresses. Bills are divided into groups of about 400, which constitute a "book" of a size convenient for regulating the flow of the work and for balancing. It is this balancing feature which has contributed largely to the greater degree of accuracy through the mechanical verification which it provides.

WHEN a "book" of bills has been completed, the accuracy of the billing is proved before the bills are released for mailing. The charges shown on posting media for the bills in the "book" are totaled prior to the machine billing operation, separate totals being secured for the monthly service charge, the additional local messages or message units, the toll service, the adjustments necessary because of changes in service, the directory advertising, and the balance due on previous bills, each of these having a separate line on the bill form and a separate accumulating register in the machine.

These so-called "control" totals are entered on a form for the related billing book, and at the end of the run of the "book" the form is inserted in the machine and the register totals are imprinted on the form alongside the respective control totals. On the average, the control totals and the register totals are found to be in agreement for more than 90 per cent of the "books." If differences are disclosed, they are located and any necessary corrections made on the bills and in the totals. In effecting an agreement between these totals, the proof has been established that not only are the bills in balance in the aggregate, but also that the charges have been properly classified and entered on the proper lines of the bill and in the right amounts. These "book" totals are subsequently summarized and become the basis for entries of accounts receivable and revenues on the general books of the company.

Machines are also used for printing and addressing bill forms at a single operation from a continuous roll of blank paper. These finished bill forms include not only the composition of the form with its three stubs but also four address imprints and a perforation. They are produced at the rate of 2000 an hour. One of the stubs remains attached to the bill mailed to the customer, and he sends or brings it to the business office when paying the bill. The second stub is forwarded to the business office for use in collection work, while the third stub remains in the Accounting Department and becomes the record of the company's current account with the customer.

Other types of special machines are used for a variety of purposes.

THROUGH constant study of both methods and machines, the work of preparing telephone bills is keeping pace with the many other improvements being made in the handling of our business, and one of the important factors considered in reaching conclusions is that of developing both methods and machine applications that will tend to a greater degree of accuracy and promptness in our billing service.

While accuracy and promptness are primary requisites, two further quali-

ties are of importance to the success of the job as a whole: neatness and legibility of the bill forms, and ease of understanding of the various items—charges, credits, and adjustments—which comprise the total of the bill. The Methods staff of the A. T. & T. Comptroller's Department and the Commercial Engineer of the O. & E. Department have recently recommended to the Associated Companies revision of the bill forms to improve the typography, and the clarity and completeness of explanations, with corresponding improvement of the explanation of adjustments due to changes in service.

System-Wide Measurements

IT has always been the aim of the operating companies to furnish customers with a high grade of billing service, and various analyses have been made from time to time for the purpose of procuring quantitative information relative to the quality of such service; but these analyses have generally been confined to departmental studies, and have therefore reflected the limited viewpoint of departmental performance. Recognizing the importance of measuring the company over-all character of billing service in such a manner that corrective action could be applied where most needed, preliminary consideration was given by the American Company in 1936 to the development of a plan for System measurements.

This activity was carried forward jointly by the Methods Division of the Comptroller's Department and the Commercial Engineer's section of the Operation and Engineering Department of the A. T. and T. Company, with the result that a tentative plan with related reports was recommended and adopted throughout the System in March, 1937. As a result of experience in operating the plan, various modifications and changes were made until July, 1939, when the plan in its present form became effective. Under the plan, monthly reports prepared by the Associated Companies serve as a basis for System summaries compiled and issued by the American Company. Adoption of this measurement plan has helped the Associated Companies to accomplish material improvement in substantially all phases of billing service.

NOBODY likes to get bills: the pocketbook nerve is one of the average citizen's most sensitive spots. But since the rendering of telephone service requires money, and that in turn necessitates billing the users of the service, it is the accepted responsibility of the Accounting Departments throughout the System to present bills to customers which are correct, regular and up to date, business-like in appearance, and easy to understand. The constant effort to accomplish those aims has been the theme of this article. Moreover, in order that bills shall be as low as is consistent with the kind of telephone service which Americans are accustomed to and demand, the billing job, like all others, is done as efficiently and as economically as modern machines and modern methods make possible. To the achievement of "the most service, and the best . . ." which is the Bell System's avowed ideal, the billing function makes a definite contribution.

THE MOBILIZATION OF SCIENCE IN NATIONAL DEFENSE

*How the NDRC Guides the War Activities of Civilian Scientists Is Told by the Chairman of Its Transportation and Communication Division, Who Is also Chairman of Bell Laboratories**

By FRANK B. JEWETT

Probably the most difficult hurdle every industry has had to get over, in the effective introduction of scientific research as a powerful tool in its operation, has been to realize that the most profitable research is that which is carried on with the least restraint imposed by current practice. Practice can be adapted to radically new ideas, but radical ideas rarely, if ever, evolve from mere improvements in current practice.

Research in military matters is no exception. War being a very ancient art, military men are, on the whole, extremely conservative as to new tools. Like doctors, long experience has made them cautious and with possibly a more than ordinary tendency to impose on a research project requirements of current practice which, in fact, hamper rather than help. Against this tendency is the fact that they are quick to adopt the radically new once its utility is demonstrated. War, more than any other of man's activities, puts a high premium on being in the lead.

As soon as war in Europe on a vast scale was seen to be imminent, the nations there commenced frantically to mobilize and organize their scientific and technical men and resources, and to establish effective liaison between them and the combat services. For more than a year after this movement was in full swing across the Atlantic, our aloofness from the struggle and our ardent desire to keep from being sucked into the tragic maelstrom operated to prevent any effective steps in the direction of mobilizing our vast scientific resources for total war.

The military services endeavored to strengthen their scientific branches and here and there enlisted the aid of civilian science. They were hampered by inadequate funds, by the pattern of years of a starved organization imposed by an anti-war philosophy, and by the fact that civilian sciences, both fundamental and applied, were built up on a basis of operation in a slow-moving peace economy. The latter had no machinery for marshaling its forces for war and, in

* Excerpts from an address before the winter meeting of the Institute of Radio Engineers, New York, January 12, 1942.

the main, it knew little of war's requirements and frequently preferred to follow the courses it understood and liked.

But about two years ago, it became apparent to a few individuals that the *laissez-faire* approach to the mobilization of science ought to be abandoned in favor of a more direct and forceful organizational approach. At that time there existed certain technical groups and associations which, on the one hand, called for strengthening, and on the other were of suggestive value in the search for a suitable organizational set-up. I have already remarked upon the scattered technical groups and laboratories within the Army and Navy which over the years had been doing commendable work, but had been given insufficient funds and encouragement. It was, of course, obvious that as the tension of the emergency increased, the responsibilities placed upon these technical groups would mount, with a resultant need to augment their personnel; but it was equally apparent that they could not be expected to carry the full load of scientific development and adaptation.

Civilian Scientists' Participation Prior to This War

CIVILIAN participation in one way or another in the solution of military problems has come to be taken for granted. It was first given official recognition in the United States when the National Academy of Sciences was incorporated, in 1863, by an Act of Congress. The charter of the Academy requires that whenever called upon by any department of the Government, it shall investigate, examine, experiment, and report upon any subject of science or art; the actual expenses of such investigations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the Government.

The Academy is, therefore, recognized as a continuing official adviser to the Federal Government, and it must attempt to answer such questions of a scientific or technical nature as are officially submitted to it by members of Government Departments. A permanent channel of communication was thus created; but power to initiate traffic over it resides with the Government, and no auxiliary machinery was created whereby the Academy or any other civilian agency might take the initiative in bringing before the Government matters of scientific importance.

LESS than a year prior to the entry of the United States into the first World War, a significant step was taken designed to facilitate the use of the channel of communication between Government and the National Academy. In 1916, the National Research Council was created by President Wilson, and a little later was to play a part in focussing civilian effort on the military problems then arising. The National Research Council was, and is today, a subsidiary of the National Academy of Sciences and, like the Academy, is largely an advisory body only and awaits the assignment of problems by one or another branch of the Government before it can go seriously to work. Moreover, the Council, like the Academy, is not in posses-

sion of free money, a corporate laboratory and other research facilities, and is, therefore, not well constituted to conduct research work on any extensive scale.

We turn our attention, therefore, to another agency contemporaneous with the National Research Council, which was created for the express purpose of establishing coöperative effort between military and civilian groups, and which was provided by Congress with funds necessary to create research facilities and to operate them when once created. This agency is the National Advisory Committee for Aeronautics, commonly known as the NACA.

THE law which created the Committee provides that it shall "supervise and direct scientific study of the problems of flight, with a view to their practical solution," and also "direct and conduct research and experiment in aeronautics." The Committee is composed of fifteen members, including two representatives each of the War and Navy Departments. Throughout its more than twenty-five years of existence, the NACA has given ample testimony of the fruitfulness of coöperation between military and civilian groups, and, moreover, has provided a prototype as to an organizational arrangement for effecting such coöperative effort successfully.

When, some two years ago, the group to whom I have already referred became convinced that broader participation by civilian scientists in the whole military program was likely to be essential, they regarded the NACA as typifying the sort of organization they would like to see created. A plan was therefore drawn up envisaging a Committee composed in part of civilian scientists and in part of Army and Navy representatives. On the one hand, the Committee was charged with a broad study of the materials of warfare and, on the other, it would recommend and, if possible, initiate such research as was believed to be in the national interest.

Steps Leading to the NDRC

THE NACA was created in 1915 by an Act of Congress. The somewhat duplicative plan just referred to was submitted to President Roosevelt about a year and a half ago for such action as he saw fit to take. The proposal appealed to him, and he decided to create the Committee by Executive Order.

This Order established the Committee as a division under the Office for Emergency Management, and conferred upon them power to take the initiative in many scientific matters which they believed to have military significance. It also directed the Committee to develop broad and coordinated plans for the conduct of scientific research in the defense program, in collaboration with the War and Navy Departments; to review existing scientific research programs formulated by these Departments, as well as other agencies of the Government; and advise them with respect to the relationship of their proposed activities to the total research program. Moreover—and this is especially important—the Order directed them to initiate and support scientific research on the mechanisms and devices of warfare, with the object of

improving present ones and creating new ones.

The Order contemplated that the Committee would not operate in the field already assigned to NACA nor in the advisory field of the National Academy of Sciences and National Research Council.

PARENTHETICALLY, it might be noted that in this latter field the Academy and Council are currently engaged on advisory work for Government for which the out-of-pocket expenses alone are at the rate of much more than $1,000,000 a year. A recent count shows that the present personnel of Academy and Research Council advisory committees runs to about 225. These figures will give an idea of the vital part which these fact-finding groups are playing in the present emergency. But to be a little more specific, I might mention that one important committee of the National Academy is advising the Office of Production Management on the availability of strategic materials.

In order to formulate adequate rules for the utilization of materials of whatever sort, accurate knowledge as to their availability, as to new processes suggested for producing them, as to possible substitutes, and a thousand and one other basic questions must be answered. This can only be done by highly trained scientists and engineers. Only after they have answered can the urgent problems of proper utilization be handled. The Academy has assembled a group of the most distinguished men in the United States to give OPM this basic information.

Thus, in June, 1940, the National Defense Research Committee, more familiarly known as the NDRC, was born. It was constituted of eight members, two of these being high ranking men from the Army and Navy respectively, five more being civilians well known for their experience in organizing and directing both fundamental and applied scientific research, and, as an eighth member, the Commissioner of Patents.

The Field of the NDRC

THE Executive Order creating the NDRC omitted any reference to the biological sciences, and, in particular, to the medical sciences. However, during its first year of operation, experience accumulated to the effect that a broader program of attack would not only be useful but was, in reality, urgently demanded. This realization prompted a second approach to President Roosevelt, with the result that in June of last year he created two new functional groups.

One of these was the Committee on Medical Research, to explore its indicated territory in the same manner that the NDRC had been exploring the physical sciences. Then, over and above both the NDRC and the Committee on Medical Research, there was placed the Office of Scientific Research and Development, usually referred to as OSRD. This latter Office was placed in charge of Dr. Vannevar Bush, who until then had been Chairman of the NDRC. President Conant of Harvard was then made Chairman of the NDRC, and Dr. Newton Richards of the Medical School of the University of Pennsyl-

vania was made Chairman of the CMR.

In order to insure complete coördination of civilian and military research and development, Dr. Bush, as Director of OSRD, was provided with an advisory council consisting of the Chairmen of NDRC, CMR, and NACA; the Coördinator of Naval Research and the Special Assistant to the Secretary of War performing a somewhat similar function in that service.

The Executive Orders creating these various committees naturally had to leave indeterminate the question of financial support. They are all subsidiary to the Office for Emergency Management and, like this Office, must look to Congress for the necessary operating appropriation. Thus far the appropriations, while not munificent, have been adequate. During its first year of existence the NDRC authorized research projects which totaled about ten million dollars. At the beginning of its second year, it was granted another ten millions and this was recently augmented by several millions more. To be more specific, the OSRD, during its first year of existence, will guide the expenditure of about twenty millions throughout the whole scientific field.

* * *

NDRC Departments

THE work of the NDRC is divided into four major departments: Division A, of which Professor R. C. Tolman of California Institute of Technology is Chairman, deals with armor, bombs and ordnance, in general; Professor Roger Adams of the University of Illinois heads Division B on chemistry; Division C deals with transportation and communication, and submarine warfare, and I am its Chairman (this Division operates the subsurface warfare laboratories); finally, Division D, which deals with instruments and numerous miscellaneous projects difficult to catalog, is headed by President Compton of Massachusetts Institute of Technology. . . .

To expedite discussions, surveys, and the general handling of the work, a further breakdown has been found desirable, the result being that each Division comprises several so-called Sections. Division B on chemistry, under Professor Adams, is divided into thirty-one Sections—which stands to date as a sort of record.

THE work of a Section is entrusted to a Section Chairman, who in turn calls to his aid certain individuals who become permanent members of his Sectional Committee and who are known technically as Members. Then there are others who may be asked to render advice and assistance from time to time, and hence are called Consultants. Members and Consultants are officially appointed by the Chairman of the NDRC and are designated only after official clearance by the Army and Navy Intelligence and the FBI. Full consideration is therefore given to the basic requirements of the military services as regards the confidential handling of their problems. . . .

Neither the five civilian members of the NDRC itself nor any of the Section Chairmen, Members, or Consultants are paid from public funds. Without exception, they are loaned to the

Government by their employing organizations and frequently the loan is complete, the work being so voluminous and detailed as to require a man's full time. Thus, when I tell you that about 500 of the leading scientists of the country are encompassed in the present NDRC organization, you will see that the Federal Government and even the forgotten taxpayer are getting a lot of valuable consulting talent free of charge.

* * *

The Magnitude of Effort

THE number of NDRC projects now approved and, for the most part, contracted out to universities and industrial research laboratories stands around 600, while the number of contracting institutions is over 100; and . . . the total value of the projects thus far determined upon is upwards of twenty million dollars. . . .

The question is frequently asked as to how many technical people have been drawn into the civilian defense effort which the NDRC directs. Obviously this is quite difficult to estimate, let alone to enumerate in detail. I have already mentioned that there are about 500 scientists in the NDRC organization serving as Members, Consultants, etc. It seems likely that somewhere between two and three thousand scientists are at work on defense projects as employees of contractors, with about an equal number of less highly skilled individuals assisting them as laboratory assistants, technicians, etc.

Then, if the situation which I know to exist at the Bell Telephone Laboratories is to be taken as a criterion, we must add to this scientific group another very considerable array of technical people who call themselves engineers, as opposed to physicists and chemists—an array which, if enumerated, would no doubt total four to five thousand.

Recent figures from the Bell Telephone Laboratories might be of interest as perhaps typifying the situation found in a number of industrial laboratories which are fulfilling defense contracts, some for the NDRC and some directly for the Army and Navy. A rough count shows that about 600 of our technical staff are now engaged directly on a full-time basis on defense projects. When I say that they are "engaged directly" on defense projects, I am excluding those who by circumstances arising out of the defense program have been forced to devote themselves to such problems as the finding of substitute materials and the engineering of emergency telephone projects.

* * *

I SUPPOSE it depends upon one's point of view as to whether the effort I have just outlined appears large or small. On the one hand, it seems fairly certain that it is only a beginning, and must expand further. On the other hand, it is already certainly large when contrasted with any civilian effort which was able to assert itself during the last war. And looking back to the situation which existed a quarter of a century ago, it is difficult to understand why the then available civilian agencies were not unleashed to an extent commensurate with their obvious capabilities.

True, the National Research Coun-

cil was created to assist with the solution of defense problems, but it was, as I have pointed out, in the position of a doctor waiting for clients; it could not adopt the attitude of an aggressive salesman and initiate attacks on what it regarded to be important military problems. Hence we can declare that, as regards organization, notable progress has been made.

As to future expansion of our civilian defense effort, it is becoming increasingly essential to bear in mind the potential shortage of trained personnel. Without insinuating anything as to guilt, the chemists declare that this is a physicist's war. With about equal justice, one might say that it is a mathematician's war. The visible supply of both physicists and mathematicians has dwindled to near the vanishing point, consistent with the maintenance of anything like adequate teaching staffs in our universities. If this civilian defense effort is to expand, and such indeed now seems imperative, the limiting factor may therefore be a shortage of highly trained individuals. . . .

* * *

Shortening the Time Gap

ANOTHER present problem, and it is the last with which I shall trouble you, is one which by its existence supplies evidence that real progress has already been made in some of the research programs thus far initiated. It has to do with shortening the time gap between proven laboratory research results and the stage where mass production can be undertaken. Some of the laboratory results already achieved hold such promise that every day which intervenes before their widespread utilization becomes a serious matter. Obviously, the problems to be met here cover a wide range of equipment and materials—as wide as that marked out by the scientific results themselves—and since they involve large-scale manufacture, the whole plan must be carefully worked out with other official agencies, particularly the Office of Production Management and the armed services.

I am sure, however, that we are prepared to meet and solve these problems; and rather than be concerned with the difficulty of making progress along this avenue, I think all who are guiding the work of the NDRC would exclaim to the ranks of scientists and technicians, "Bring on your results, the more the better, and we will guarantee them a speedy passage to the firing line!"

IN the foregoing, I have attempted merely to sketch the set-up of organized civilian research and development created for the war emergency. Obviously, it is only a part of the total effort which is being mobilized. It would be unfair to thousands of scientists and engineers to imply that the main results were dependent on the work of these agencies.

The scientific departments of the armed services are being greatly enlarged; industrial laboratories are turning more and more of their efforts to direct and indirect war work; and engineers everywhere are active. Fundamental and applied science are on the march.

FOR THE RECORD

M. R. SULLIVAN AND C. O. BICKELHAUPT ELECTED A. T. & T. VICE PRESIDENTS

Two recently elected Vice Presidents of the American Telephone and Telegraph Company are Mark R. Sullivan, who since 1939 has been Vice President of the Pacific Telephone and Telegraph Company in charge of operations, and Carroll O. Bickelhaupt, who has been since 1930 an Assistant Vice President of the A. T. and T. Company.

Mr. Sullivan, whose election was effective last December 1, is now in charge of the Department of Operation and Engineering during the absence on leave of Vice President W. H. Harrison in Washington as head of the Production Division of the War Production Board. A native of Oakland, Cal., Mr. Sullivan started his telephone career in 1912, at the age of 19, as a clerk in the office of the division traffic engineer in San Francisco. Progressing through the Pacific Company's traffic organization, he held, among others, the posts of division traffic supervisor, general toll supervisor, and general traffic supervisor. In 1928 he became general traffic manager for the Northern California and Nevada area, and in 1934 vice president and general manager for that area. Four years later his duties as vice president were made company-wide as chief of staff of the operating vice president's organization. In 1939 he was elected vice president in charge of operations—the position he held at the time of his election to the A. T. and T. Company.

Mr. Bickelhaupt was elected, on December 17, Vice President of the A. T. and T. Company with special duties on National Defense matters. He commanded a Signal Corps battalion in the first World War, has been continuously active since that time in the Signal Corps Reserve, and is at present on leave of absence for military service as Colonel, Signal Corps, on duty in the Office of the Chief Signal Officer of the Army, War Department. Born in Roscoe, South Dakota, he began telephone work during school vacations with the Dakota Central Telephone Company at Aberdeen, S. D. After graduation from the University of Wisconsin in 1911, he joined the A. T. and T. Company in New York as a junior engineer in the commercial engineering division. In 1922, having served, among other offices, as toll rate engineer and toll traffic engineer, he became commercial engineer. He was elected, in 1925, Vice President of the Southern Bell Telephone and Telegraph Company in charge of operations, continuing in this position for five years. In 1930 he was made an Assistant Vice President of the A. T. and T. Company.

ISAIAH BOWMAN ELECTED AN A. T. & T. DIRECTOR

On January 21, Isaiah Bowman was elected a Director of the American Telephone and Telegraph Company, to fill the vacancy created by the resignation of

Barklie Henry, a Director since 1939, who has been called to active duty by the Navy. Dr. Bowman is President of Johns Hopkins University.

NET TELEPHONE GAIN IN 1941 WAS 1,360,000

In 1941 there was a net gain of about 1,360,000 telephones in service in the principal telephone subsidiaries of the American Telephone and Telegraph Company included in the Bell System. This was the largest increase for one year in the history of the Bell System. The largest previous annual gain was 950,000 in 1940. At the end of December, 1941, there were about 18,840,000 telephones in the Bell System.

The gain during the month of December, 1941, was about 130,100. This was the largest December gain in the history of the Bell System. The gain for the previous month was 102,100, and for December, 1940, it was 111,300.

The total number of telephones in the United States which can be interconnected, including those of the Bell System and several thousand independent telephone companies, was about 23,430,000 at the end of 1941.

CONTRIBUTORS TO THIS ISSUE

Entering Yale in 1914, Judson S. Bradley left college in 1917 to enlist in the U. S. Army Ambulance Service. Returning from overseas in 1919, he reentered college, and received his B.A. degree in 1920. For the next four years he was assistant editor and managing editor of the *Yale Alumni Weekly*. In 1925 he joined the Publicity Department of the Southern New England Telephone Company, in New Haven, as copy writer, and was subsequently advertising manager until 1928. In that year he was transferred to the Commercial Division of the American Telephone and Telegraph Company, and in 1930 became a member of the staff of the General Information Department. He has contributed a number of articles to the Bell Telephone Quarterly and its successor, this Magazine, of which the most recent was "The Bell System and National Defense," in the issue for February, 1941.

[Photographs from commercial agencies used in his article: Acme, pp. 6, 10, 11; Press Association, p. 8; Wide World, p. 16.]

Joining the New York Telephone Company in 1922, Jerome D. Towe filled a number of assignments in business office work in New York City and Paterson, N. J., in the the next several years. In 1925 he became a business office manager at Paterson and, with the organization of the New Jersey Area of the New York Company, was appointed successively directory compilation supervisor and directory production manager for that area and later for the New Jersey Bell Telephone Company. In 1929 he was transferred to the Department of Operation and Engineering of the American Telephone and Telegraph Company, where, in the Commercial Division, his present assignment is in the group engaged on directory service and production matters.

After receiving a B.A. degree in English Literature from the University of Colorado in 1925 and pursuing special courses in writing and English at Columbia University, Stuart Shaw was for two and a half years a newspaper reporter in Denver before he joined the publicity department of the Mountain States Telephone and Telegraph Company as a writer in 1928. Since 1930 he has been editor of the company's employee magazine, *The Monitor*.

Mr. Shaw's article gives evidence of the versatility of the *Monitor's* staff; for the two maps are by Miss Beulah Black, staff artist, and the accompanying photographs are by Lawrence Effinger, editorial assistant. While the latter was making those "stills," Mr. Shaw, whose hobby is photography, was busy taking motion pictures of the same and other construction scenes. In connection with identifying the pictures which are reproduced with his article, Mr. Shaw wrote:

"As a matter of passing interest, that picture on the top of Argentine Pass represents a lot of leg work. The road is now not much more than a horse trail, though previous to 1879 it was the stage road between Georgetown and Leadville, famous mining camps of the early west. Mr. Effinger and I started up there . . . in a light pick-up truck equipped with double reduction gear. We put on tire chains to provide traction on the steep grade, but soon began running into mud and snow. After digging the car out several times, we decided it would be easier to walk up. So, loaded with movie and still equipment, we started out from about 11,000 feet to make our way to the top at something over 13,000 feet. If you don't think that a climb like that will make a couple of office workers pant and blow, you are mistaken. Well, skipping over a lot of anguish of soul and body, we finally got there and it really was worth the effort. We were lucky to have struck one of the few clear, quiet days to be found at that altitude. The country stretched out in all directions in a manner that I am going to sidestep by calling indescribable. There is peace, and an ageless quality to those hills. . . . There is no sound but the sound the Indians knew before the white man came."

The Bell System career of F. Raymond Brewster started in the Accounting Department of the New York Telephone Company in 1899, but was terminated temporarily when he entered the public accounting field in 1904. Returning to the Bell System in 1906, he progressed through field and methods staff positions in connection with the customers' accounting work in the New York Telephone Company, and in 1919 joined the staff of the Comptroller of the American Telephone and Telegraph Company in charge of customers' accounting methods. During this period the practices of the Bell System underwent fundamental changes, including the substitution of small stubs in place of heavy ledgers for keeping customers' accounts, and also the adoption of "rotation" billing and the use of machines in place of longhand entries—both of which are mentioned in his article. In 1936 he was appointed General Supervisor of Methods in the Comptroller's Department, the position he now holds.

It was in 1904 that Frank B. Jewett left the teaching staff of Massachusetts Institute of Technology to join the engineering department of the A. T. and T. Company. He had been graduated from Throop Polytechnic Institute (now California Institute of Technology) with the B.A. degree in 1898, and had received his Ph.D. degree from the University of Chicago in 1902. From 1908 to 1912 he was transmission and protection engineer of the A. T. & T. Co. In the latter year he was transferred to the Western Electric Company as Assistant Chief Engineer, and became Chief Engineer of the

company in 1916 and Vice President in 1922. In 1925 he was elected Vice President of the A. T. & T. Co., and in the same year was also made President of the Bell Telephone Laboratories. The latter office he resigned in 1940, becoming Chairman of the Board. He was awarded the Distinguished Service Medal for his work in the first World War, has received a number of honorary degrees, medals, and awards, and is active in numerous educational and scientific organizations. He has served since April, 1939, as President of the National Academy of Sciences, and as head of the division of transportation and communication in the National Defense Research Council since June of 1940.